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Cockpit Control System
Conceptual Design

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1. Project Summary

1.1 Design Goals

The purpose of this project was to provide a means for operating the ailerons, elevator, elevator trim, rudder, nosewheel steering, and brakes in the Triton primary flight trainer. The main design goals under consideration were to illustrate system and subsystem integration, control functionability and producibility. Weight and maintenance goals were addressed.

1.2 Statement of Work Requirements

The Statement of Work for the cockpit control system set forth several design requirements. The location of fundamental components of the control systems and their relative position within the aircraft structure must be designed. Accessibility of the mechanical control assemblies for adjustments and maintenance must be provided. Geometric travel and forces required on the cockpit controls must conform to FAR Part 23. These motions should not be rough, have slack or tension due to temperature gradients, bind, chafe or lock up when their deflection is maximized as dictated in the work statement. Finally, with the FAR Part 23 limit load applied in the cockpit, the movement of the control surfaces must be limited by stops at the points of maximum deflection and at the yoke. Adverse effects due to varying environmental conditions must be addressed to provide a service life of twenty years and 10,000 operational mission cycles.

Summary of Critical Detail Parts

Part No. (Dwg #)	Title	Load(s)	Load Source	Associated Fastener	M.S./type (part)	M.S./type (fitting)	Page No.
2 (01)	Telescoping Tube	41,415 psi	Yoke	Fafion[R] fbjw bearing	0.04/Y	N/A	15
8 (01)	Pulley E4	206.5 lb	Cable	NAS334-5	1.42/U	12.9	13
23 (01)	Elevator Control Tube	38,360 psi	Yoke Assem.	Fafion[R] fbjw bearing	0.12/Y	N/A	15
27 (01)	Rud. Pedal Torque Tube	28,805 psi	Rud. Pedals	Fafion[R] fbjw bearing	0.49/Y	N/A	14
21 (03)	Nosewheel P/P Rod	920 psi	Rud. Pedals	HMX-6FG/AN6H13	0.20/Y	3.51	14

Table 1

2. Description of the Design

2.1 Yoke Assembly

Yoke assemblies in existing aircraft were examined for feasibility in the Triton. A modified Piper Navajo design (see Reference 1) was chosen primarily for its fit characteristics. This assembly does not employ a floor mounted "T" column, thereby conserving floor space for other aircraft control systems and structure. The elevator control quadrant is in the center section of the control rod to allow for simple cable routing through the center of the aircraft. To support the center section of the elevator control tube, a center bearing support mounted to the firewall was added to absorb the bending loads imposed by the quadrant. Figure 1 below shows the top view of the yoke assembly and the center support for the elevator control tube.

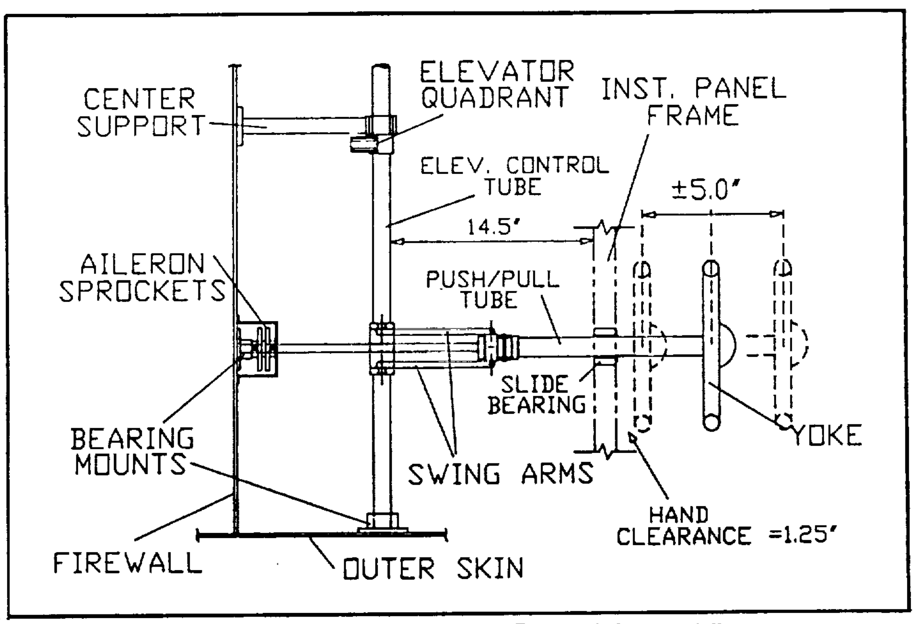


Figure 1: Top View of Yoke Control Assemblies

Rotation of the yoke ninety degrees in each direction from the neutral position deflects the ailerons 20° upwards and 10° downwards as required by the statement of work. The rotation of the yoke turns either of two square shafts which are subsequently attached axially to two chain sprockets. The rear sprocket controls the ailerons while the front sprocket causes an identical motion in the second yoke. Moving the yoke fore and aft a maximum of 5 inches in each direction (10 inches total travel) produces an elevator deflection of $\pm 20°$ through induced motions of the cable quadrant on the control rod.

2.2 Aileron Control System

Existing systems currently used in other aircraft were examined to aid in designing the differential Frise aileron control system. After routing over the 2.86" diameter aileron sprocket at the yoke assembly, the linkage transitions from chain to cable. This cable is then routed around the left side of the aircraft, and then to a pulley assembly mounted on the front structural I-beam at Station 63.6 shown in Figure 2 below.

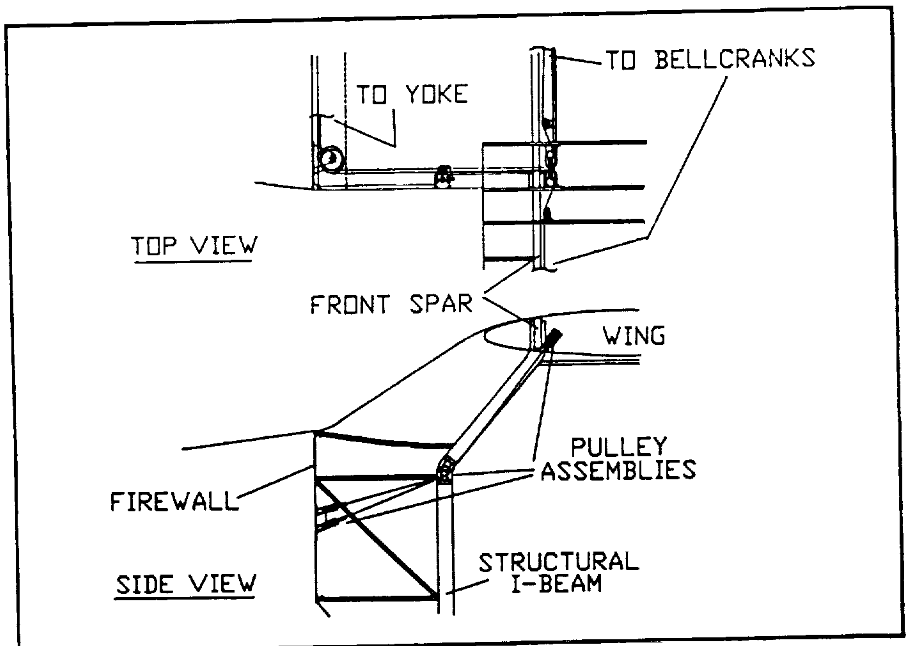


Figure 2: Top and Side View of Aileron Cable Routing to Wing

The pulley mount at the central bend of the I-beam holds two tandem 1.75" pulleys and is attached to the neutral axis of the I-beam. The mount has a rectangular plate wedged between the flanges which prevents any bending due to pulley loads. Also, the pulleys on this mount are offset such that one cable can emerge on the aft side and the other on the front side of the beam. This beam also supports the next pulley mount (4.25" pulleys) at the top portion of the beam at Station 83.2

(see Figure 2). Here the pulleys cause the cables to travel in opposite directions, one to each wing bellcrank. The bellcrank has three attachments: two for the aileron cables and one for the push rod which goes aft to the aileron control horn. There are also two 1.75" pulleys located in the rear of the wing as a guide for the cable which controls the differential aspect of the ailerons. Figure 3 below shows the top view of the aileron bellcrank. Figure 4 below shows the differential deflection of the ailerons.

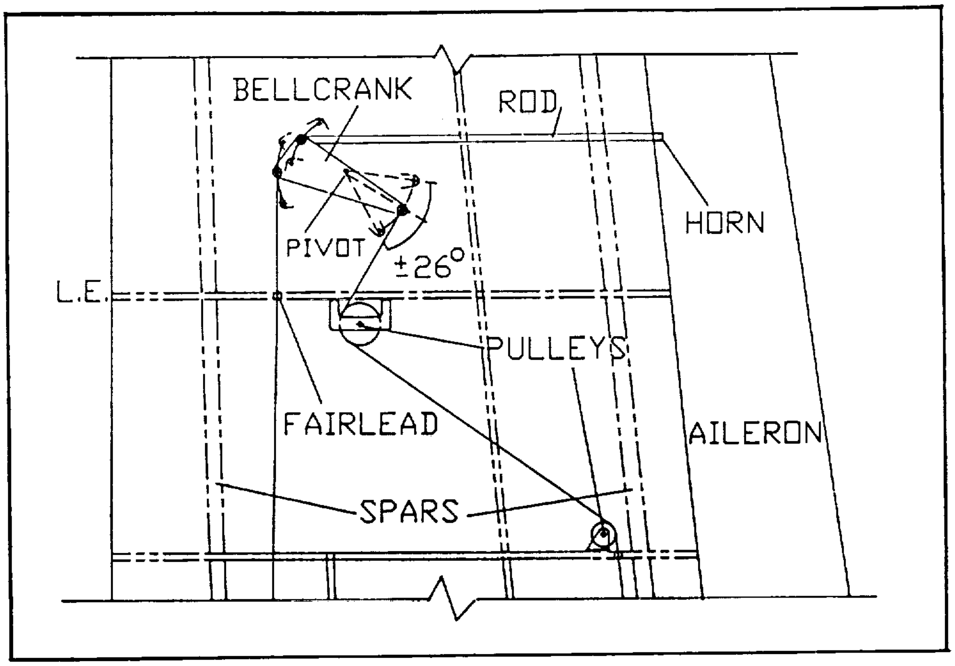


Figure 3: Top View of Aileron Bellcrank and Cable Routing

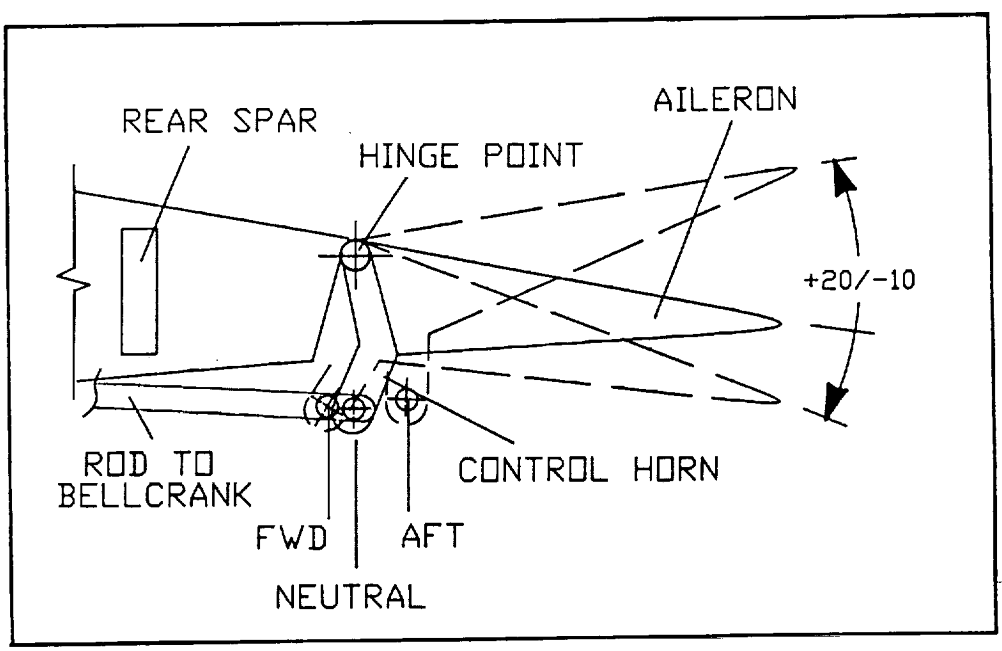


Figure 4: Side View of Differential Aileron Deflection

2.3 Elevator Control System

The elevator control system is mounted under the floor along with the elevator trim and rudder control systems for ease of cable routing. The elevator cables are on the inside "track" of the system. The design incorporates pulley "gangs" such that all control systems would have pulleys mounted on the same axis at the same stations. The pulley gang located at station 168.0 is shown in Figure 5 below. The first pulley mount is located above the elevator quadrant assembly at STA 43.5, WL 55.1 and holds a single 4.13" pulley (pulley E1). The second pulley mount which holds two 4.13" pulleys is near the firewall directly below pulley E1 at STA 43.5, WL 32.5. The cables are then mounted to a third pulley mount with two 4.13" pulleys located under the forward section of the floor at STA 51.5, WL 21.5. Figure 6, located on the following page shows the side view of the yoke control system, and the elevator pulley system described above.

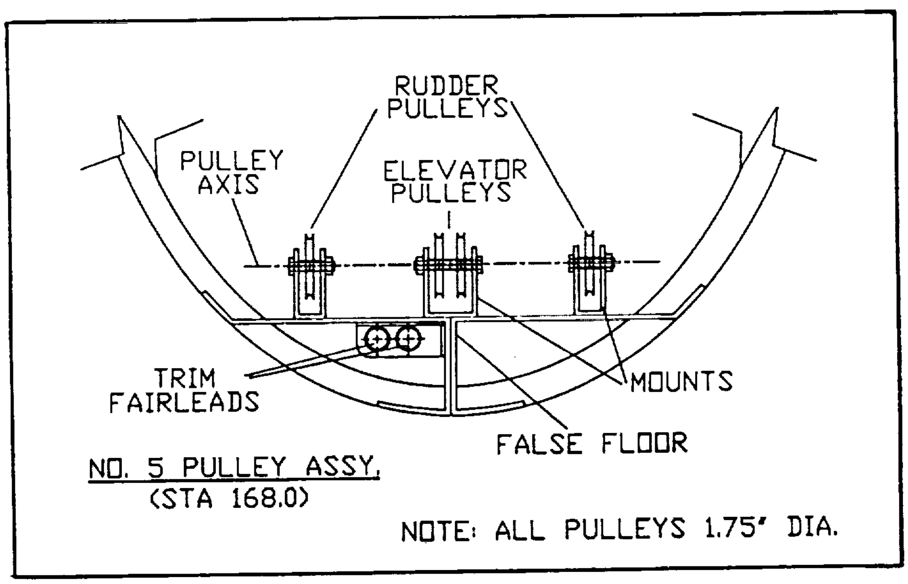


Figure 5: Front View of No. 5 Pulley Assembly (STA 168.0)

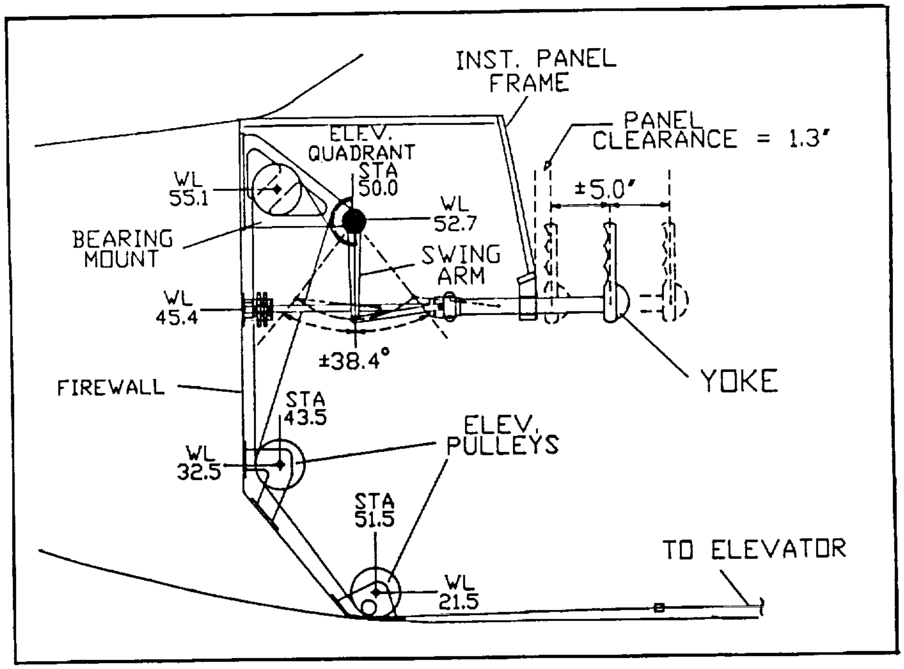


Figure 6: Side View of Yoke Control and Elevator Pulley Systems

The next set of pulleys are 1.75" in diameter and are located at Station 98 behind the landing gear in the aft section of the floor. This pulley mount in connection with the fifth mount at Station 168 (also 1.75" pulleys) will direct the cables through a cross section change in the aircraft. The final guide is a fairlead assembly which is mounted in the empennage at Station 228.1 for all cables travelling to the elevator and rudder. The two cables are attached to an elevator control horn whose axis is on the hinge line of the elevator. Figure 7 and Figure 8 on the following page show the fairlead assembly and the elevator torque tube respectively.

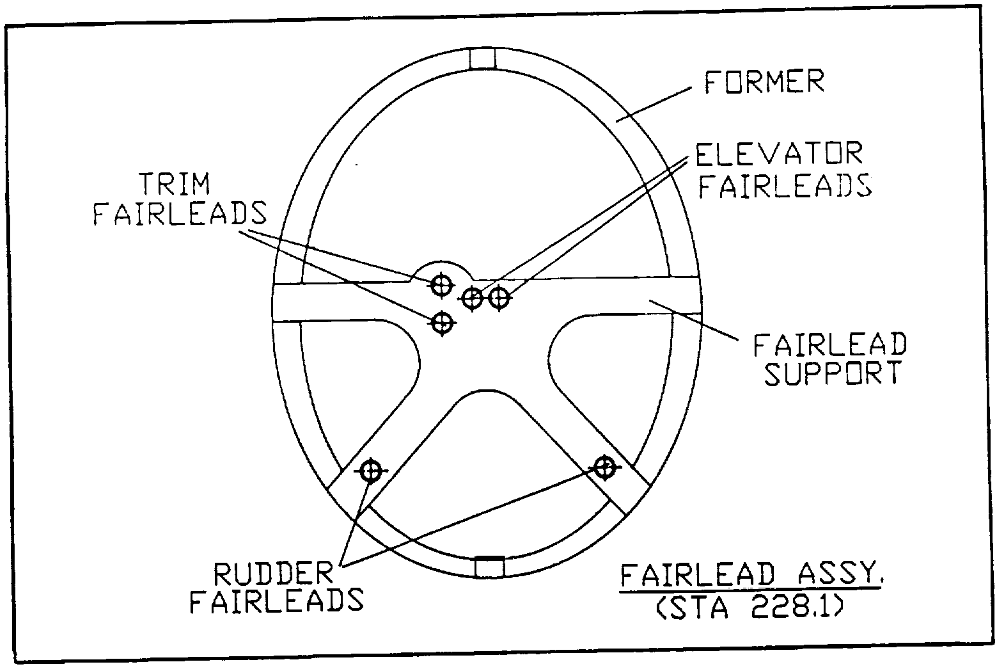


Figure 7: Front View of Fairlead Assembly (STA 228.1)

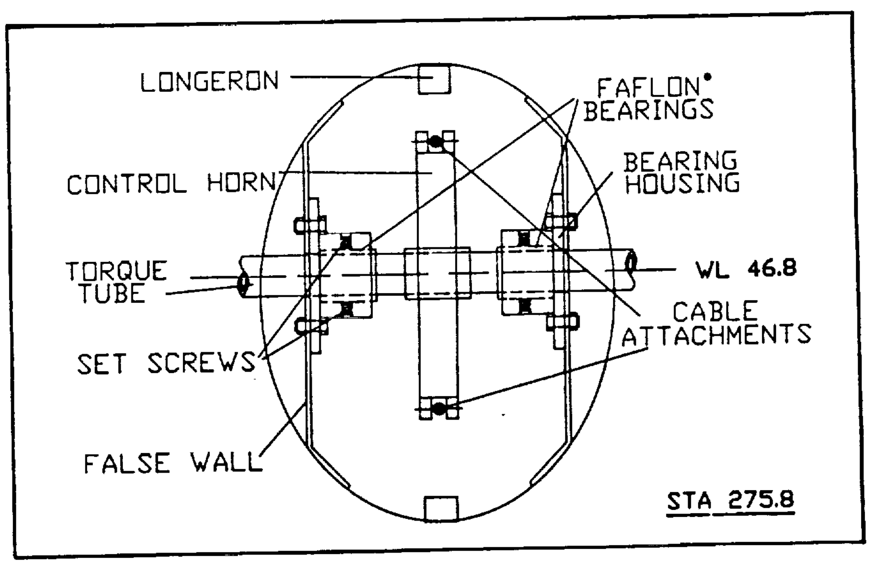


Figure 8: Front View of Elevator Control Horn Mounting (STA 275.8)

2.3.1 Elevator Trim Control System

The elevator trim control system utilizes an adjustment wheel located on a raised floor section between the seats. This system closely resembles that of the Cessna 172. The large wheel rotates a small sprocket which allows for fine tuning of the elevator trim tab. The smaller (1/16") cables and pulleys for this system are mounted on the left side of the elevator and rudder cables until the last pulley gang. At this point, the trim cables are run along the left bottom side of the empennage through the fairlead assembly to a final pulley which routs the cables into the left side of the horizontal stabilizer where it transitions to chain. The chain rotates a sprocket equal in diameter to that of the trim wheel which drives a screwjack assembly that deflects the trim tab. Figure 9 below shows the top view of the elevator trim control located in the horizontal stabilizer.

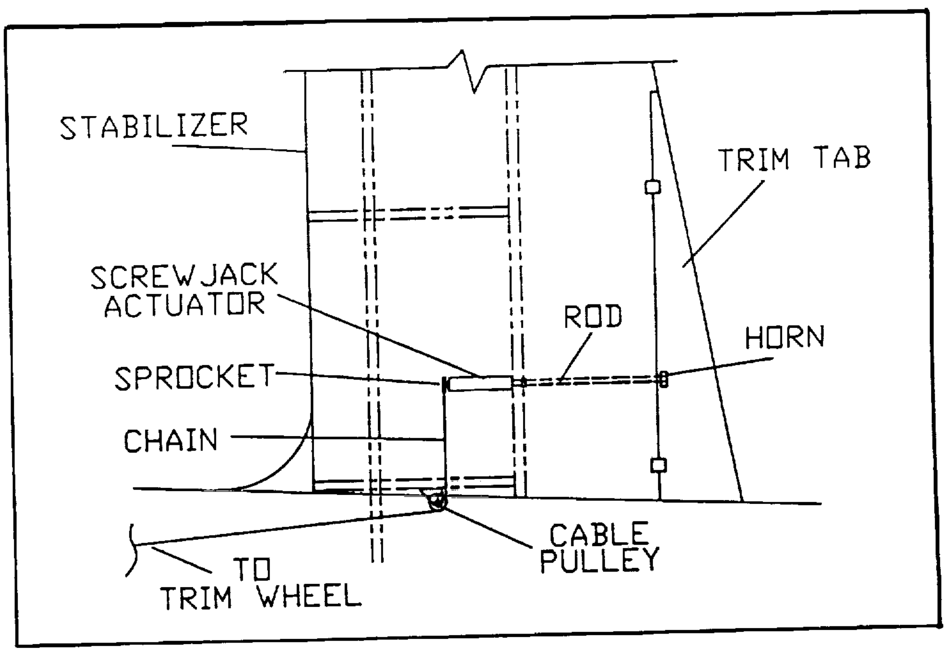


Figure 9: Top View of Elevator Trim Control

2.4 Rudder and Nosewheel Steering Control Systems

The rudder pedal assembly was adapted from the Lake Amphibian (see Reference 2). This configuration employs rudder pedal torque tubes which serve three main functions: rudder deflection, braking, and nosewheel steering. Both the left and right rudder pedals are mounted on independent torque tubes to provide identical motions for each pilot. When a pedal is depressed, the torque tube rotates a control arm beneath the floor which causes rudder cable deflection as well as rotation of the nosewheel. When the top of a pedal is rotated downward, its master cylinder is depressed which actuates brake calipers in the main landing gear as shown in Figure 10 below.

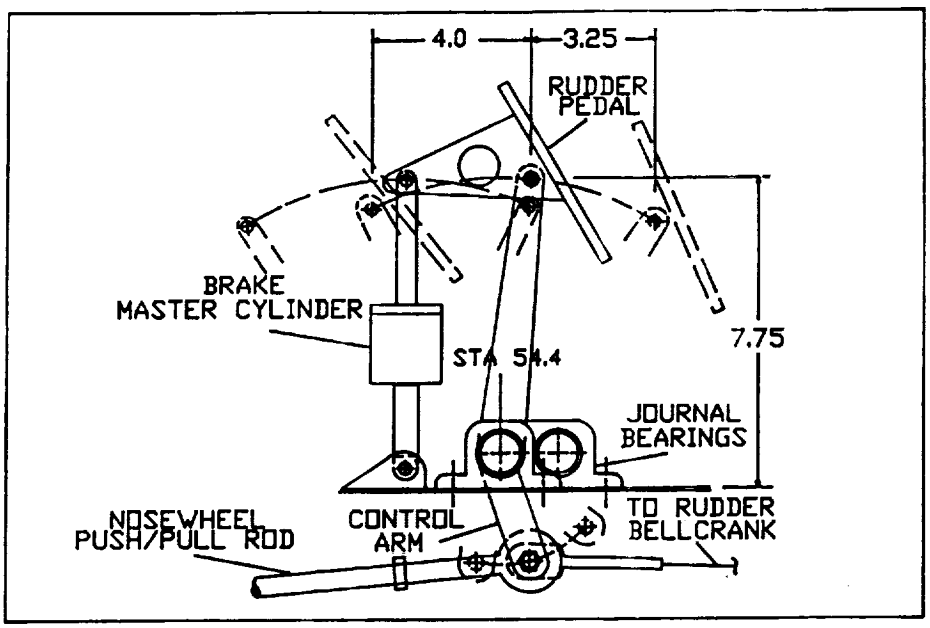


Figure 10: Side View of Rudder Pedal Assembly

2.4.1 Rudder Control System

The rudder pedals rotate about 7.0" arms which also rotate 2.77" control arm underneath the floor. The rudder cables and nosewheel control rods are attached to the lower arms. The rudder pedals have a four inch deflection in either direction from the neutral point (see Figure 9 above) which yields a maximum cable deflection of 1.37"; this translates into the required rudder deflection of 20°

right or left. The rudder cables are routed outside of the elevator control cables. After leaving the rudder control arms, the control cables are incorporated into the pulley gang at the baggage compartment station. The cables then run along the bottom of the empennage to the same fairlead assembly (Figure 6) which directs the elevator and trim tab cables. The rudder cables remain well below all elevator systems. A second set of fairleads directs each rudder cable to its appropriate height once they are behind the elevator control arm. The cables cross after these fairleads; so, the rudder deflects in the proper direction with corresponding rudder pedal deflection.

2.4.2 Nosewheel Steering

The nosewheel steering uses two push-pull rods connected to the 2.77" control arms mentioned in section 2.4 of this report. With maximum deflection of the rudder pedals, the push-pull rods also translate through 1.37". These push-pull rods are connected directly to the 4" control horns on either side of the nosewheel, yielding a maximum deflection of 20° left or right. The push-pull rods are directed through the firewall under the floor with boot at the intersection and do not interfere with any major engine components.

2.5 Environmental Considerations

The design of all control systems makes use of stainless steel cable which demonstrates no adverse thermal expansion problems with respect to the temperature gradients set forth by the statement of work. All bearings which are susceptible to sand and dust are faflon[R] fbjw bearings and have dust seals to protect against particle build up leading to failure. All ball bearing mechanisms are contained in sealed shrouds which minimizes problems with particle debris.

3. Loads and Loading

With a maximum pilot control input of 200 pounds on the elevator at the control yoke, the critical load occurs in the telescoping tube. This input loads translates into an estimated stress of 41,415 psi on the telescoping tube. The stress is the sum of the axial and torsional stresses on the tube, including a fitting factor of 2.5 for the bearings. The axial load imposed on the tube is translated through a control collar which translates torque to the elevator control tube. These forces are then transmitted to the elevator quadrant, center support, bearing supports, and control cables. The fourth elevator pulleys carry the critical load of 206.5 lbs each. This and other pulleys carry the cable loads to the pulley mounts, ribs, stringers, and skin of the aircraft.

The instantaneous application of all maximum pilot control forces results in the critical stress of 38,360 psi on the elevator control tube. This stress is a combination of flexural bending, shear due to transverse loads in bending, torsional shear, and simple shear. These stresses were combined using Mohr's circle to find the principle stress. The tube is mounted to the firewall and existing aircraft structure and transmits all input loads to the appropriate control cables. The control cables then transmit cable forces into the pulley mounts which flow into the aircraft skin.

With a maximum input load of 200 lbs per rudder pedal, the torque tube experiences a critical stress of 28,805 psi. This stress is the sum of flexural bending stress and shear stress due to transverse loads in bending. The loads in the rudder pedal torque tubes transmit loads to the skin through both the faflon[R] journal bearings, nosewheel steering rods, and the pulley mounts.

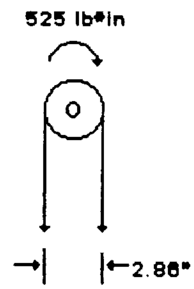
4. Structural Substantiation

Force in the cables of the aileron control system.

D is the diameter of the yoke.
F_{wa} is the force in the wheel due to aileron control loading as specified by FAR Part 23.
F_{ca} is the force in the aileron control cables due to the applied force descirbed above.

D_{sa} is the diameter of the aileron control sprockets.

Aileron Control Sprocket



$D := 10.5 \cdot in$ $\quad F_{wa} := 50 \cdot lb \cdot D$ $\quad F_{wa} = 43.75 \cdot lb \cdot in$

$D_{sa} := 2.8684 \cdot in$ $\quad F_{ca} := \frac{F_{wa}}{D_{sa}}$

$F_{ca} = 183.03 \cdot lb$

Force in the cables of the elevator control system.

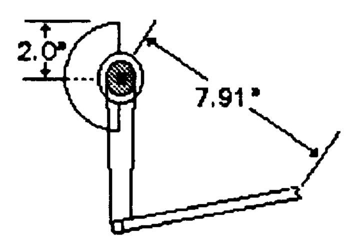
F_{we} is the force in the wheel due to elevator control loading as specified by FAR Part 23.

F_{ce} is the force in the elevator control cables due to the applied force described above.

l_a is the length of the elevator arms.

r_q is the radius of the elevator control quadrant.

Elevator Quadrant Assembly



$F_{we} := 200 \cdot lb$ $\quad l_a := 7.91 \cdot in$ $\quad r_q := 2.0 \cdot in$

$F_{ce} := \frac{F_{we} \cdot l_a}{r_q}$ $\quad F_{ce} = 791 \cdot lb$

Force in the cables of the rudder control system.

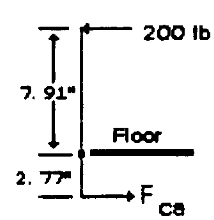
F_r is the force on the rudder pedal due to rudder control loading as specified by FAR Part 23.

F_{cr} is the force in the rudder control cables due to the applied force described above.

l_{aa} is the length of the moment arm above the floor.

l_{au} is the length of the moment arm underneath the floor.

Rudder Actuating Arms



$F_r := 200 \cdot lb$ $\quad l_{aa} := 7.00 \cdot in$ $\quad l_{au} := 2.77 \cdot in$

$F_{cr} := \frac{F_r \cdot l_{aa}}{l_{au}}$ $\quad F_{cr} = 505.42 \cdot lb$

Forces on the pulleys.

$x := 1,2..14$

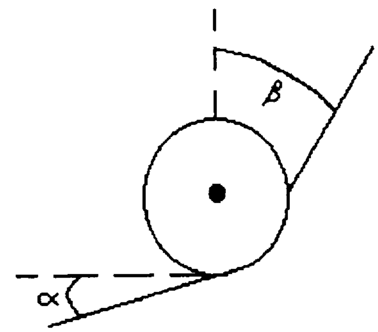
$y := 1,2..14$ **Note** Pulleys are in the following order : A1-A6, E1-E5, and R1-R3.

$z := 1,2..14$

The tangent angles are as follows :

$\alpha_x :=$	$\beta_y :=$
0	0
12	35
-22	90
0	-22
0	0
-50	90
16	-74
0	35
0	35
0	75
0	85
-55	90
0	75
0	85

General Pulley Assembly



The forces on each of the pulleys are :

$$F_{p_z} := 2 \cdot F_{ca} \cdot \cos\left[\frac{\alpha_x + 180 - \beta_y}{2} \cdot \left(\frac{3.1416}{180}\right)\right]$$

$F_{p_1} := 258.84 \cdot lb$

$F_{p_2} := 134.16 \cdot lb$

$F_{p_3} := 303.50 \cdot lb$

$F_{p_4} := 69.85 \cdot lb$

$F_{p_5} := 258.84 \cdot lb$

$F_{p_6} := 154.70 \cdot lb$

$F_{p_7} := 1519.0 \cdot lb$

$F_{p_8} := 730.50 \cdot lb$

$F_{p_9} := 730.50 \cdot lb$

$F_{p_{10}} := 206.50 \cdot lb$

$F_{p_{11}} := 69.00 \cdot lb$

$F_{p_{12}} := 466.80 \cdot lb$

$F_{p_{13}} := 132.00 \cdot lb$

$F_{p_{14}} := 49.85 \cdot lb$

Pulley E4, labeled as F_{p10} in these calculations, is a critical detail part. The 1.75 in pulley can maintain 500 lbs. This results in a margin of safety of:

$$MS := \frac{500 \cdot lb}{F_{p_{10}}} - 1$$

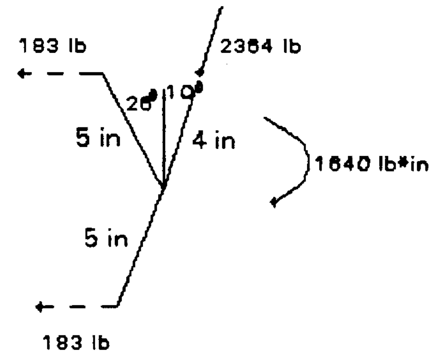
$MS = 1.42$

Sizing the aileron push pull rod from forces on the bellcrank.

P is the axial load in the aileron push pull rod.
σ is the yield strength of 2024-T3 aluminum tubing.
D_O is the outer diameter of the tubing.

Assumed: $d_o := 0.50 \cdot in$

Geometric representation of the Aileron Bellcrank



$P := 2364 \cdot lb$ $\qquad$ $\sigma_y := 43000 \cdot lb \cdot in^{-2}$

$A := \dfrac{P}{\sigma_y}$ $\qquad$ $A = 3.82 \cdot 10^{-4} \cdot in^2$

$d_i := \left(\dfrac{\pi \cdot d_o^{\,2} - 4 \cdot A}{\pi}\right)^{.5}$ $\qquad$ $d_i = 0.04 \cdot in$

Therefore, a tube with an inner d_i of .370 in was chosen.

Sizing the nosewheel push pull rods.

The nose wheel push pull rods were sized, using the same formula, to have a d_o of 0.375 in and d_i of 0.34 in.

The axial load in these rods is 706 lb. which yields a stress of 35,920 psi.. Therefore the margin of safety is:

$\sigma := 35920 \cdot lb \cdot in^{-2}$

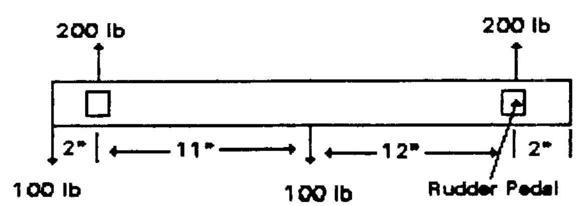
$MS := \dfrac{43000 \cdot lb \cdot in^{-2}}{\sigma} - 1$

$MS = 0.2$

The rod was later sized up to a 0.5 in outer diameter and 0.43 in inner diameter due to its length of 38 inches.

Sizing the rudder pedal torque tube.

Rudder Pedal Torque Tube



Assumed: $c := 0.5 \cdot in$ $\qquad$ $t := .065 \cdot in$

$M := 100 \cdot 12 \cdot lb \cdot in$ $\qquad$ $I := .02097 \cdot in^4$

$\sigma := \dfrac{M \cdot c}{I}$ $\qquad$ $\sigma = 4.12 \cdot 10^6 \cdot lb \cdot in^{-2}$

$V := 100 \cdot lb$ $\qquad$ $Q := 0.5 \cdot .19093 \cdot 0.0276 \cdot in^3$

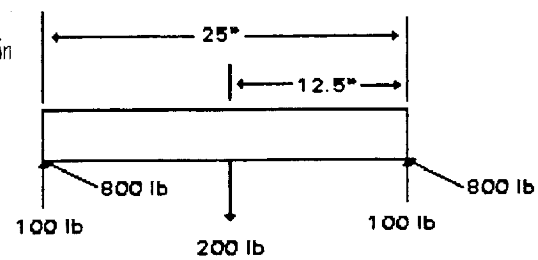
$\tau := \dfrac{V \cdot Q}{I \cdot t}$ $\qquad$ $\tau = 2.78 \cdot 10^4 \cdot lb \cdot in^{-2}$ $\qquad$ $\sigma_t := \sigma + \tau$ $\qquad$ $\sigma_t = 4.15 \cdot 10^6 \cdot lb \cdot in^{-2}$

$MS := \dfrac{43000 \cdot lb \cdot in^{-2}}{\sigma_t} - 1$ $\qquad$ $MS = 0.49$

Sizing the elevator control tube.

Some of the above formulas were used in this analysis.

Elevator Control Tube



Assumed: $I := .02097 \cdot in^4$ $\quad c := 0.5 \cdot in$ $\quad t := .065 \cdot in$

$V := 100 \cdot lb$ $\quad Q := .5 \cdot .19093 \cdot .02759 \cdot in^3$ $\quad J := 2 \cdot .02097 \cdot in^4$

$M := 100 \cdot 12.5 \cdot lb \cdot in$ $\quad T := 1600 \cdot lb \cdot in$

$\sigma := \frac{M \cdot c}{I}$ $\quad \sigma := 2.98 \cdot 10^4 \cdot lb \cdot in^{-2}$

$P := 800 \cdot lb$ $\quad A := .19093 \cdot in^2$

$\tau_1 := \frac{V \cdot Q}{I \cdot t}$ $\quad \tau_2 := \frac{P}{A}$ $\quad \tau_3 := \frac{T \cdot c}{J}$

$\tau_1 = 2.78 \cdot 10^4 \cdot lb \cdot in^{-2}$ $\quad \tau_2 := 4190 \cdot lb \cdot in^{-2}$ $\quad \tau_3 = 2.75 \cdot 10^6 \cdot lb \cdot in^{-2}$

$\tau_t := \tau_1 + \tau_2 + \tau_3$ $\quad \tau_t = 3.38 \cdot 10^6 \cdot lb \cdot in^{-2}$

σ_1 is the principle stress using Mohr's circle. $\sigma_1 := 38360 \cdot lb \cdot in^{-2}$

Therefore, the margin of safety is:

$MS := \frac{43000 \cdot lb \cdot in^{-2}}{\sigma_1} - 1$ $\quad MS = 0.12$

Sizing the telescoping tube.

Assumed: $T := 525 \cdot lb \cdot in$ $\quad c := .625 \cdot in$ $\quad J := 2 \cdot .0426 \cdot in^4$ $\quad t := .065 \cdot in$

$\tau := \frac{T \cdot c}{J}$ $\quad \tau := 3851.2 \cdot lb \cdot in^{-2}$

$P := 200 \cdot lb$ $\quad A := 0.242 \cdot 4 \cdot 0.25 \cdot 0.065 \cdot in^2$

$\sigma := \frac{P}{A}$ $\quad \sigma := 12715 \cdot lb \cdot in^{-2}$

F.F. of 2.5 allowed.

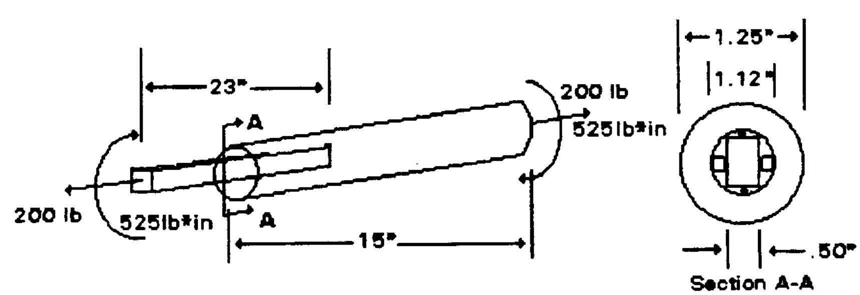
$\sigma_t := (\tau + \sigma) \cdot 2.5$

$\sigma_t := 41416 \cdot lb \cdot in^{-2}$

$MS := \frac{43000 \cdot lb \cdot in^{-2}}{\sigma_t} - 1$

$MS = 0.04$

Telescoping Tube and Square Shaft



5. Manufacturing and Maintenance Provisions

5.1 Aileron System Maintenance

The aileron sprockets on the yoke assembly control rod are inspected from inside the cockpit by looking underneath the instrument panel. Panels covering the I-beam structure on the inside of the cockpit are removable to allow for maintenance and inspection of the aileron cables, turnbuckles, and pulleys. The pulleys which run to the bellcranks and the bellcranks themselves are inspected either by removing the outboard section of the wing or through small access panels on the underside of the wing. The aileron push-pull rods are also accessible through the same access panels where the bellcranks are located as well as from outside of the aircraft where they join the aileron horns.

5.2 Elevator, Elevator Trim, and Rudder Systems Maintenance

As is the case for all yoke-related systems, the elevator pulley quadrant is accessed from inside the cockpit underneath the instrument panel. The first set of elevator, rudder, and trim assembly pulleys are examined by removing the raised floor access panel located between the seats in the forward section of the aircraft. In addition, the rudder control arms and the points at which the rudder cables are connected to the arms are accessible through this floor panel. Any adjustments in the cables are accomplished at this section since all of the turnbuckles are located here. The second set of pulleys which direct the elevator, elevator trim, and the rudder cables are accessed through a second removable panel just aft of the seats below the baggage rack. The cables in the pulley gang, located at the empennage bulkhead, are accessed from inside the cabin through a panel mounted on the aft bulkhead. The cable fairleads are reached through an external access panel on the underside of the empennage. The elevator control horn is inspected through a circular access panel on the side of the empennage. The elevator trim screwjack and pulley are inspected through a circular access panel on top of the horizontal stabilizer. The cables connections to the rudder control horns are external to provide easy inspection.

5.3 Manufacturing

5.3.1 Yoke Control Assembly

The control wheels, elevator control tube, faflon^{R} bearings, square shafts, and telescoping tubes are all purchased from vendors. The telescoping tube is machined to house bearings upon which the square shaft travels. The elevator control tube is machined to provide mounting areas for attached control systems. This machining provides a series of welded tubes and rods. The rods have keyways machined to accommodate control linkage attachments, such as the elevator quadrant and cast swing arms.

5.3.2 Aileron Control System

All items in this assembly are vendor supplied with the exception of the pulley mounts, bellcranks, and control horns. The bellcranks and pulley mounts are stamped from sheet aluminum and machined. The control horns are cast from aluminum.

5.3.3 Elevator Control System

The pulleys, pulley mount fasteners, and torque tube are vendor supplied. The pulley mounts are stamped from sheet aluminum and machined. The torque tube is machined once it is purchased from the vendor. The machining of the torque tube includes welding the cast control horns to the tube. The control horns, arms, and quadrant are cast from aluminum and machined. The control cables are attached to the control horn with eye ends.

5.3.4 Rudder Control System

The pulleys, rudder pedals, torque tubes, faflon^{R} journal bearings, and master cylinders are vendor supplied. The torque tubes are machined once they are purchased from the vendor. The rudder pedal torque tube is made of a welded tube/rod construction with machined keyways for the rudder pedals and control arms. The rudder control horn, control arms, and bearing supports are cast from aluminum with a casting factor of 1.25 to 1.5 as specified by FAR Part 23. The cables are attached to the control arms with forked ends and to the control horn with eye ends.

5.3.5 Nosewheel Steering System

The nosewheel push-pull rods are purchased from a vendor. The nosewheel steering horn is forged from aluminum. The push-pull rods are attached to the control arms with male threaded rod ends.

6. Weight Summary

Part Number (Dwg #)	Title	Number Used	Weight per part (lb)	Total Weight (lb)
1 (01)	Control Yoke†	2	0.94	1.88
23 (01)	Elevator Control Tube†	1	0.96	0.96
7 (01)	Square Shaft†	2	0.67	1.34
2 (01)	Telescoping Tube†	2	0.20	0.40
–	Faflon® Bearing Assem†	11	0.33	3.63
12 (01)	Aileron Sprocket†	3	0.34	1.02
22 (01)	Elevator Quadrant†	1	0.30	0.30
9 (01)	Elevator Arm†	2	0.40	0.80
–	Pulley Mount†	18	0.10	1.80
16 (01)	Pulley A1†	2	0.50	1.00
17, 19 (01)	Pulleys A2, A4, A6	5	0.21	1.05
18 (01)	Pulleys A3, A5	4	0.35	1.40
6, 7, 8 (01)	Pulleys E1, E2, E3†	5	0.49	2.45
9, 10 (01)	Pulleys E4, E5	4	0.21	0.84
Section B-B (02)	Pulleys R1, R2	4	0.21	0.84
11 (01)	Fairlead Assembly	1	0.25	0.25
15 (01)	Aileron Bellcrank	2	2.00	4.00
5 (02)	Aileron P/P Rods	2	0.18	0.36
1 (02)	Aileron Control Horn	2	0.20	0.40
12 (01)	Elev. Control Horn	1	0.40	0.40
11 (02)	Elev. Torque Tube	1	0.23	0.23
27 (01)	Rudder Pedal Torque Tube†	2	0.75	1.50
17 (03)	Rudder Pedals†	4	0.40	1.60
19 (03)	Master Cylinder†	4	0.50	2.00
21 (03)	Nosewheel P/P Rod†	2	0.16	0.32
6 (03)	Nosewheel Control Horn	2	0.20	0.40
23 (03)	Rudder Control Horn	2	0.20	0.40
				†Cockpit Total Weight: 20.00 lb
				Total Weight: 32.57 lb.

Table 2

6.1 Weight Comparison

The values given in the following tables are compared to the reference values shown in Appendix 2. The values in Appendix 2 are the preliminary design weight allowances for the control systems of the Triton. The actual estimated weights are listed in the tables below.

Part Classification: Miscellaneous Nosewheel Struts Allowed Weight: 4.0 lbs

Part	Estimated Weight (lbs)
Nosewheel P/P Rod	0.32
Nosewheel Control Horn	0.40
TOTAL ESTIMATED WEIGHT	0.72

Table 3

Part Classification: Control Yoke Allowed Weight: 10.0 lbs

Part	Estimated Weight (lbs)
Control Yoke	1.88
Elevator Control Tube	0.96
Square Shaft	1.34
Telescoping Tube	0.40
Faflon[R] Bearing Assem.	3.63
TOTAL ESTIMATED WEIGHT	8.21

Table 4

Part Classification: Rudder/Brake Pedals   Allowed Weight: 12.0 lbs

Part	Estimated Weight (lbs)
Rudder Pedal Torque Tube	1.50
Rudder Pedals	1.60
Master Cylinders	2.00
TOTAL ESTIMATED WEIGHT	5.10

Table 5

Part Classification: Control Linkage and Misc. Controls   Allowed Weight: 19.0 lbs

Part	Estimated Weight (lbs)
Aileron Sprocket	1.02
Elevator Quadrant	0.30
Elevator Swing Arms	0.80
Pulley Mounts	1.80
Pulley A1	1.00
Pulleys A2, A4, A6	1.05
Pulleys A3, A5	1.40
Pulleys E1, E2, E3	2.45
Pulleys E4, E5	0.84
Pulleys R1, R2	0.84
Fairlead Assembly	0.25
Aileron Bellcranks	4.00
Aileron Push/Pull Rods	0.36
Aileron Control Horns	0.40
Elevator Control Horn	0.40
Elevator Torque Tube	0.23
Rudder Control Horn	0.40
TOTAL ESTIMATED WEIGHT	17.54

Table 6

7. Conclusions

The design presented provides a means for operating the ailerons, elevator, elevator trim, rudder, and nosewheel steering. All requirements set forth in the statement of work are met by the final design. Calculations and detailed analysis required significant changes in the original design for the rudder system only. The original design for the rudder control employed a torque tube mounted in the rear of the empennage with offset control arms and push-pull rods. However, after sizing calculations were performed, it was determined the system would not fit in the empennage at the desired section. The rudder was simplified in the final design to employ only cables and pulleys with two offset control arms located on the rudder itself.

reduction depending upon the accuracy and reliability of the date.

(c) Pilot forces used for design are assumed to act at the appropriate control grips or pads as they would in flight, and to react at the attachments of the control system to the control surface horns.

§ 23.397 Limit control forces and torques.

(a) In the control surface flight loading condition, the airloads on movable surfaces and the corresponding deflections need not exceed those that would result in flight from the application of any pilot force within the ranges specified in paragraph (b) of this section. In applying this criterion, the effects of control system boost and servo-mechanisms, and the effects of tabs must be considered. The automatic pilot effort must be used for design if it alone can produce higher control surface loads than the human pilot.

(b) The limit pilot forces and torques are as follows:

Control	Maximum forces to torques for design weight, weight equal to or less than 5,000 pounds [1]	Minimum forces or torques [2]
Aileron:		
Stick	67 lbs.	40 lbs.
Wheel [3]	50 D in.lbs.[4]	40 D in.-lbs.[4]
Elevator:		
Stick	167 lbs.	100 lbs.
Wheel (symmetrical	200 lbs.	100 lbs.
Wheel (symmetrical [5]		100 lbs.
Rudder	200 lbs.	130 lbs.

[1] For design weight (W) more than 5,000 pounds, the specified maximum values must be increased linearly with weight to 1.18 times the specified values at a design weight of 12,500 pounds [, and for commuter category airplanes, the specified values must be increased linearly with weight to 1.35 times the specified values at a design weight of 19,000 pounds.]

[2] If the design of any individual set of control systems or surfaces makes these specified minimum forces or torques inapplicable, values corresponding to the present hinge moments obtained under sec. 23.415, but not less than 0.6 of the specified minimum forces or torques, may be used.

[3] The critical parts of the aileron control system must also be designed for a single tangential force with a limit value of 1.25 times the couple force determined from the above criteria.

[4] D = wheel diameter (inches).

[5] The unsymmetrical force must be applied at one of the normal handgrip points on the control wheel.

§ 23.399 Dual control system.

Each dual control system must be designed for the pilots operating in opposition, using individual pilot forces not less than—

(a) 0.75 times those obtained under § 23.395; or

(b) The minimum forces specified in § 23.397(b).

§ 23.405 Secondary control system.

Secondary controls, such as wheel brakes, spoilers, and tab controls, must be designed for the maximum forces that a pilot is likely to apply to those controls.

§ 23.407 Trim tab effects.

The effects of trim tabs on the control surface design conditions must be accounted for only where the surface loads are limited by maximum pilot effort. In these cases, the tabs are considered to be deflected in the direction that would assist the pilot. These deflections must correspond to the maximum degree of "out of trim" expected at the speed for the condition under consideration.

§ 23.409 Tabs.

Control surface tabs must be designed for the most severe combination of airspeed and tab deflection likely to be obtained within the flight envelope for any usable loading condition.

§ 23.415 Ground gust conditions.

(a) The control system must be investigated as follows for control surface loads due to ground gusts and taxiing downwind:

(1) If an investigation of the control system for ground gust loads is not required by subparagraph (2) of this paragraph, but the applicant elects to design a part of the control system for these loads, these loads need only be carried from control surface horns through the nearest stops or gust locks and their supporting structures.

(2) If pilot forces less than the minimums specified in § 23.397(b) are used for design, the effects of surface loads due to ground gusts and taxiing downwind must be investi-

COMPONENT	WEIGHT :	STA	MOMENT :	WL	MOMENT
SPINNER	1.3	15.6	20.28	45.6	59.28
PROPELLER	19	16.2	307.8	45.6	866.4
ENGINE	225	28.5	6412.5	40.8	9180
BATTERY	22.6	54	1220.4	54	1220.4
ENG. MOUNT/BOLTS	10.4	50.4	524.16	40.8	424.32
EXHAUST SYS.	7	48	336	32.4	226.8
COWLING (UPPER)	3	44.4	133.2	50.4	151.2
COWLING (LOWER)	5	43.2	216	34.8	174
HINGES	3	18	54	49.2	147.6
NSW. OLEO	26	39	1014	24	624
NOSEWHEEL	9.7	31.2	302.64	6	58.2
MISC. NSW. STRUTS	4	48	192	25.8	103.2
MAIN GEAR STRUT	90	115.2	10368	18	1620
MAIN GEAR TIRES	70	115.2	8064	8.4	588
MAIN GEAR BRAKES	3.3	115.2	380.16	8.4	27.72
FUSELAGE STRUC.	188.8	156	29452.8	45.6	8609.28
DOORS	14	108	1512	39.6	554.4
DOOR WINDOWS	4	108	432	61.2	244.8
WINDSHIELD	8.4	78	655.2	68.4	574.56
REAR WINDOW	10	162	1620	63.6	636
BAGGAGE RACK	1.8	132	237.6	30	54
SKYLIGHT	4	120	480	81.6	326.4
TOTAL WING	259	114	29526	78	20202
HORIZ. TAIL	21.6	284.4	6143.04	44.4	959.04
VERT. TAIL	13.8	318	4388.4	58.8	811.44
LANDING LIGHTS	1	95.4	95.4	79.2	79.2
FLAP MECHANISM	12	125.5	1506	76.8	921.6
FUEL TANKS	14.8	116.5	1724.2	77	1139.6
WING ATTACH PINS	8	118.8	950.4	78	624
FUEL SYSTEM	4.7	80.4	377.88	50.4	236.88
INSTRUMENT PANEL	12	82.8	993.6	56.4	676.8
INSTRUMENTS	62	73.2	4538.4	54	3348
CONTROL YOKE	10	90	900	49.2	492
RUDDER/BRAKE PDLS	12	69	828	27.6	331.2
SEATS	60	114	6840	42	2520
CONTROL LINKAGE	12	78	936	34.8	417.6
SEATBELTS	4	114	456	40.8	163.2
MISC. CONTROLS	7	90	630	48	336
EMER LOCATR. XMTTR	4	186	744	36	144
WING/FUSE FILLETS	5	119	595	73.2	366
H. TAIL FAIRINGS	6	271.2	1627.2	44.4	266.4
V. TAIL FAIRINGS	2	279.6	559.2	56.4	112.8

Appendix 3 - References

1. "Piper Navajo Service Manual." Piper Aircraft Corporation March 1990. 1:I4.

2. "Maintenance Manual/Service Catalog." Lake Aircraft Corporation Sept. 1992. 20: C23-24.

Appendix 4 – Disk Menu Index

Filename	Program	File Description
REPORT	WordPerfect	A disk copy of the written report.
CALCS.MCD	MathCAD	Calculations used in report Section 4: Structural Substantiation.
01-01SYS.SKD	AutoSketch	Control System Installation – shows system orientation inside airframe.
01-02SYS.SKD	AutoSketch	Control System Installation – shows related cross-sections from 01-01SYS.SKD.
01-03SYS.SKD	AutoSketch	Control System Installation – shows turnbuckle assembly, fairlead, and cable connection detail.
02-01YOK.SKD	AutoSketch	Cockpit Yoke Assembly – side view of yoke assembly and its mounting arrangement inside cockpit.
02-02YOK.SKD	AutoSketch	Cockpit Yoke Assembly – top view of yoke assembly and mounting.
03-01RUD.SKD	AutoSketch	Rudder/Nosewheel Horn Detail – detail of nosewheel control arm and rudder control horn.
03-02RUD.SKD	AutoSketch	Rudder/Brake Assembly – side view and detail of rudder pedal assembly.
03-03RUD.SKD	AutoSketch	Rudder/Brake Assembly – top view of rudder pedal bar and its mounting inside cockpit.
04-01ELE.SKD	AutoSketch	Elevator System Component Detail – shows detail of elevator cable pulleys, mounts, and control horn.
05-01AIL.SKD	AutoSketch	Aileron System Component Detail – shows detail of aileron cable pulleys, mounts, and bellcrank arrangement.

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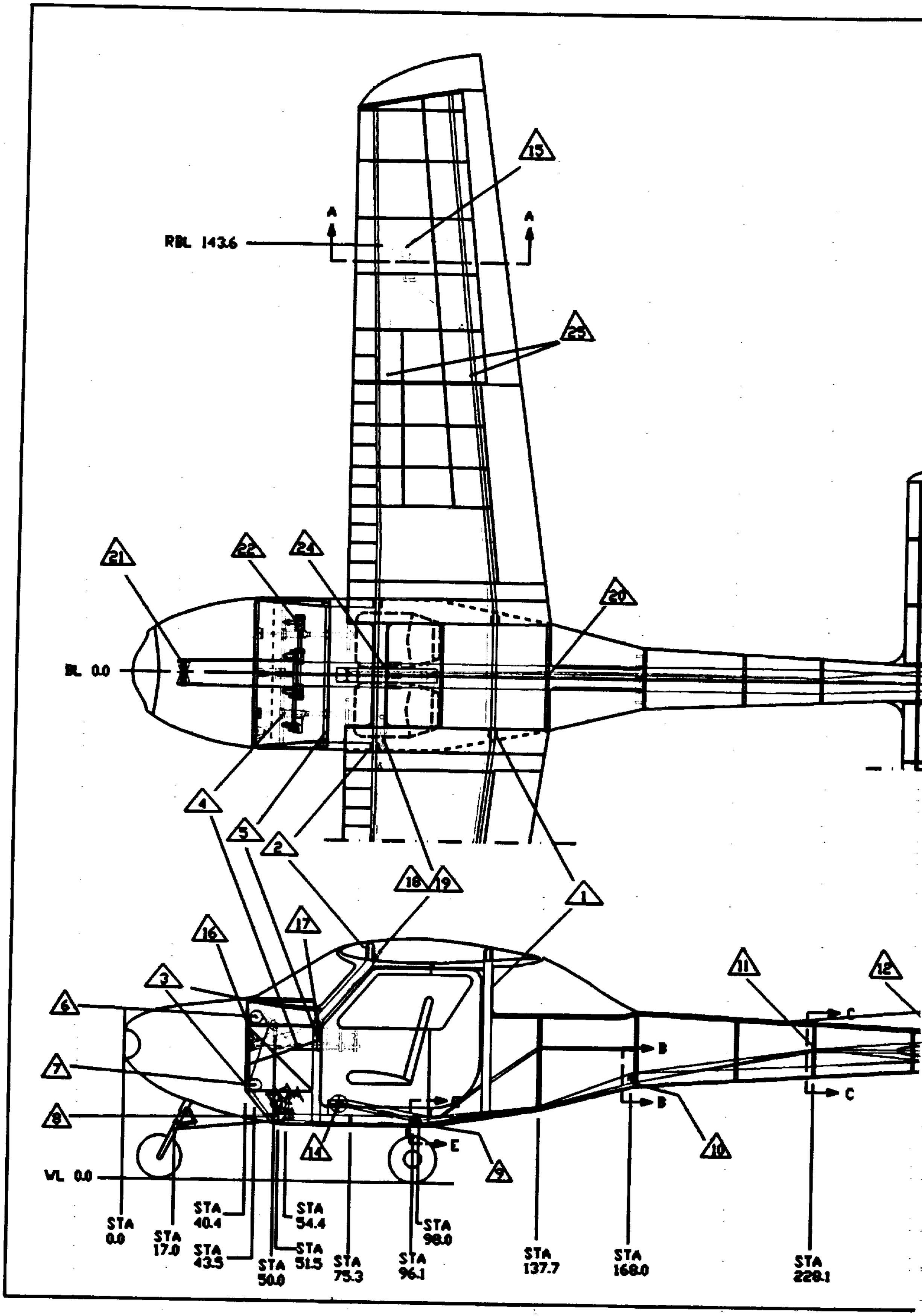

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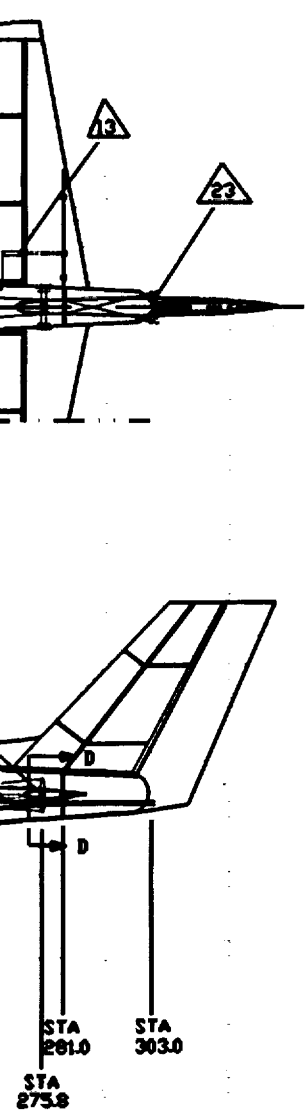

ITEM	DESCRIPTION	DRAWING/SHEET NO. 421S9303B1xx-xx
25	AILERON CABLE CONNECTIONS	01-03
24	ADJUSTMENT TURNBUCKLE	01-03
23	RUDDER CONTROL HORN ASSY.	03-01
22	RUDDER PEDAL ASSY.	03-02,03
21	NOSEWHEEL CONTROL ASSY.	03-01
20	FAIRLEAD TYP. (3/4" O.D.)	01-03
19	NO. A4 PULLEY ASSY.	05-01
18	NO. A3 PULLEY ASSY.	05-01
17	NO. A2 PULLEY ASSY.	05-01
16	NO. A1 PULLEY ASSY.	05-01
15	AILERON BELLCRANK ASSY.	05-01
14	TRIMWHEEL	01-01
13	TRIM SYS. SCREWJACK MECH.	01-01
12	ELEVATOR CONTROL HORN	01-02,04-01
11	FAIRLEAD ASSY.	01-02
10	NO. 5 PULLEY ASSY.	01-02
9	NO. 4 PULLEY ASSY.	01-02
8	NO. 3 PULLEY ASSY.	04-01
7	NO. 2 PULLEY ASSY.	04-01
6	NO. 1 PULLEY ASSY.	01-01
5	YOKE SUPPORT STRUCTURE	02-01,02
4	COCKPIT YOKE ASSEMBLY	02-01,02
3	FIREWALL REINF. BEAMS	01-01
2	FORWARD STRUC'L I-BEAM	01-01
1	AFT STRUC'L I-BEAM	01-01

PARTS LIST

LAYER	DESCRIPTION	LINE COLOR
ALL	PULLEY MOUNT ARRANGEMENT	GREEN
10	DIMENSIONS AND LABELS	BLACK
8	AIRCRAFT DETAIL OUTLINE	BLACK
7	RUDDER/NOSEWH'L SYSTEM	MAGENTA
6	AILERON SYSTEM LAYOUT	YELLOW
5	ELEVATOR TRIM SYSTEM	LT. BLUE
4	ELEVATOR SYSTEM LAYOUT	DK. BLUE
3	COCKPIT YOKE ASSY.	GREEN
2	INTERNAL STRUCTURAL ARR.	RED
1	AIRCRAFT OUTLINE	BLACK

LAYER AND COLOR KEY

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	SIZE D	DATE 2/22/93	SCALE 1/20	DRAWN BY G. MEHOLIC
	TITLE CONTROL SYSTEM INSTALLATION			
	DRAWING NO. 421S9303B101			SHEET 01

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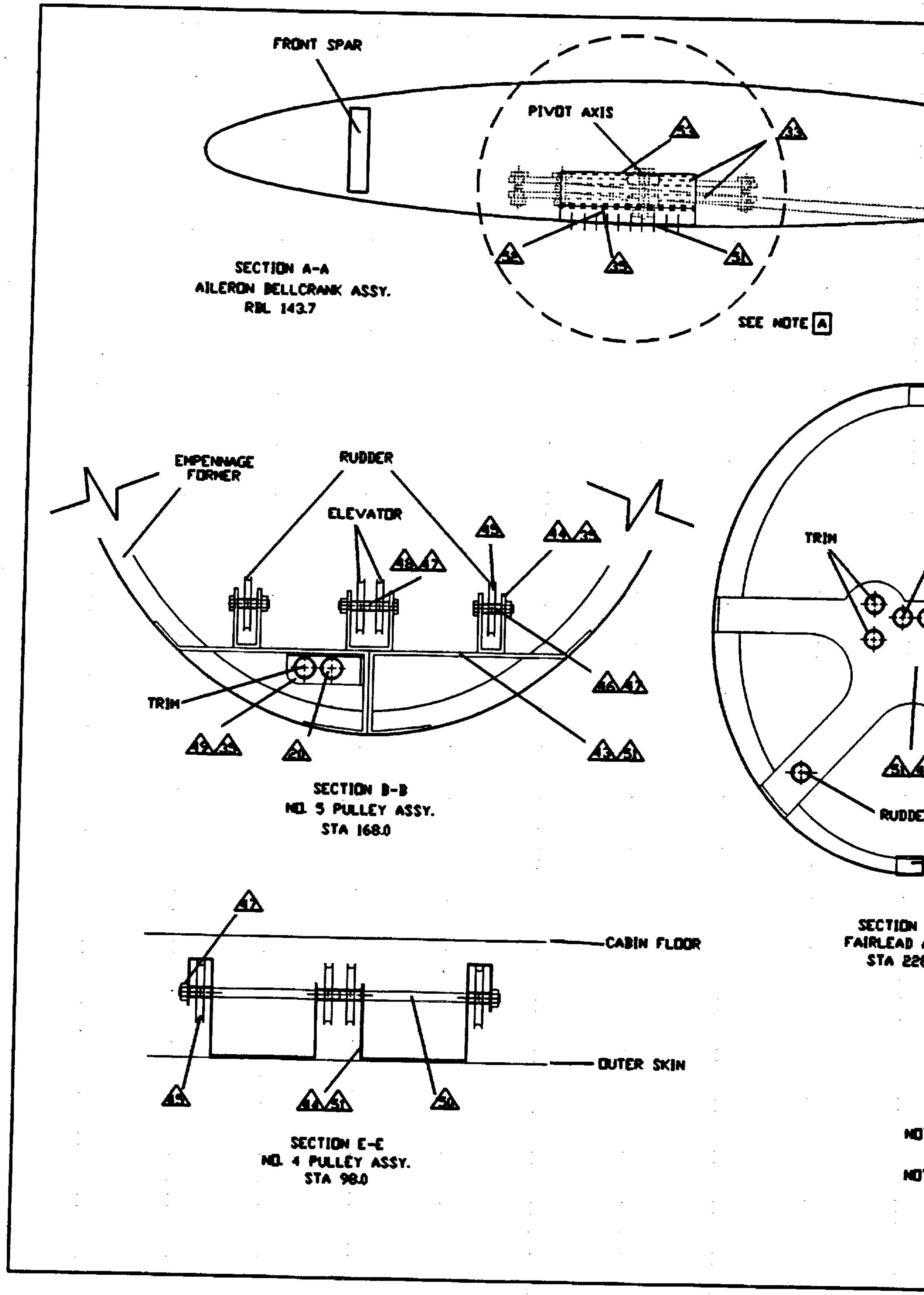

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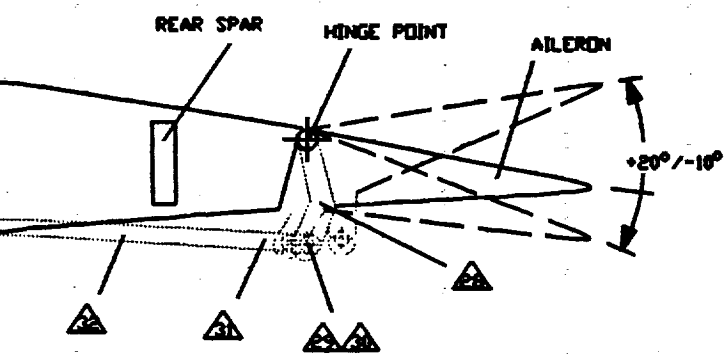

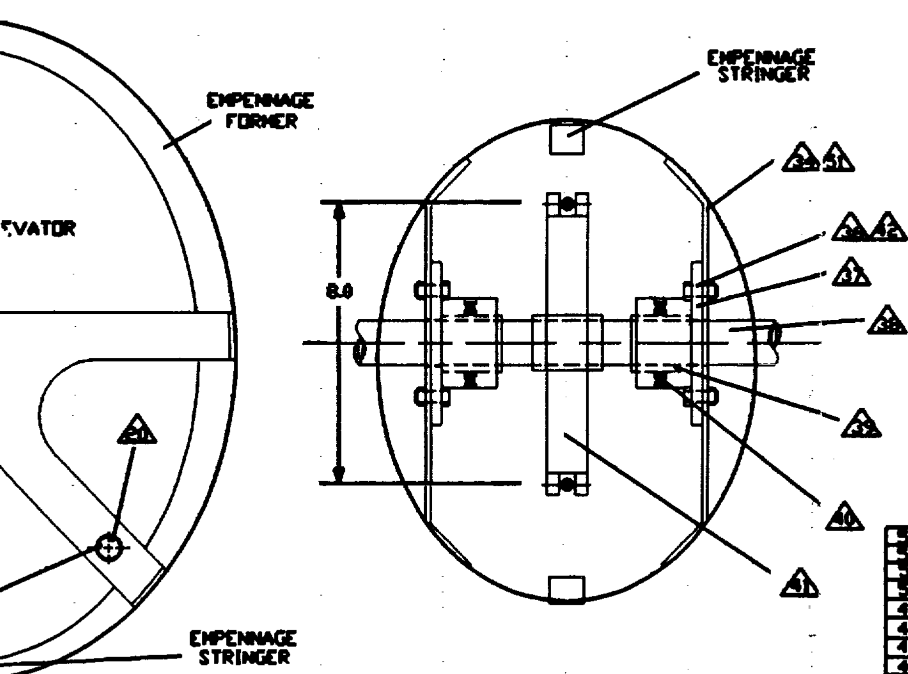

-C
SSY.

SECTION D-D
ELEVATOR CONTROL HORN MOUNTING
STA 275.8
(SEE NOTE [B])

E [A]: TOP VIEW OF BELLCRANK ON DRAWING NO. 421S9303B105-01

E [B]: SIDE VIEW OF ELEVATOR CONTROL HORN ON DRAWING NO. 421S9303B104-01

ITEM	QTY	DESCRIPTION	SIZE OR NO
53	2	BELLCRANK MOUNT (6061-T6 SHT.)	0.063" THK.
52	2	FALSE FLOOR (6061-T6 SHT.)	0.063" THK.
51	232	RIVET, FLUSH HEAD	MS20426DD3-4
50	1	ROD, 4130 THD. 5/16"-28 AT ENDS	5/16" O.D.
49	3	FAIRLEAD SUPPORT (2024-T3 SHT.)	0.032" THK.
48	1	BOLT, TYP.	AN5-11
47	2	NUT, TYP.	AN364-528
46	2	BOLT, TYP.	AN5-16
45	8	CABLE PULLEY, TYP.	AN220-1
44	5	PULLEY MOUNT (2024-T3 SHT.)	0.032" THK.
43	2	FALSE FLOOR (2024-T3 SHT.)	0.032" THK.
42	4	NUT, TYP.	AN365-528
41	1	ELEV. CONTROL HORN (CAST 7075)	
40	4	SET SCREW	AN526-832-6
39	2	FABRIC BEARING (FAFNIR Fb.w)	1.25" I.D.
38	1	ELEV. TORQUE TUBE (6061-T6)	1.25" O.D.
37	2	BEARING HOUSING (CAST 2024)	
36	4	BOLT, TYP.	AN5-6
35	60	RIVET, TYP.	MS20430DD2-4
34	2	FALSE WALL (2024-T3 SHT.)	0.032" THK.
33	4	BELLCRANK PLATE (CAST 7075)	0.125" THK.
32	2	CONTROL ROD (TUBING, 6061-T6)	0.5" O.D.
31	4	ROD END	HMX-6FG
30	2	NUT, CASTLE TYPE	AN320-6
29	2	BOLT, TYP.	AN6H13
28	2	AILERON HORN (CAST 7075)	

PARTS LIST

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	SIZE D	DATE 2/22/93	SCALE	DRAWN BY G. NEHOLIC
	TITLE CONTROL SYSTEM INSTALLATION			
	DRAWING NO. 421S9303B101			SHEET 02

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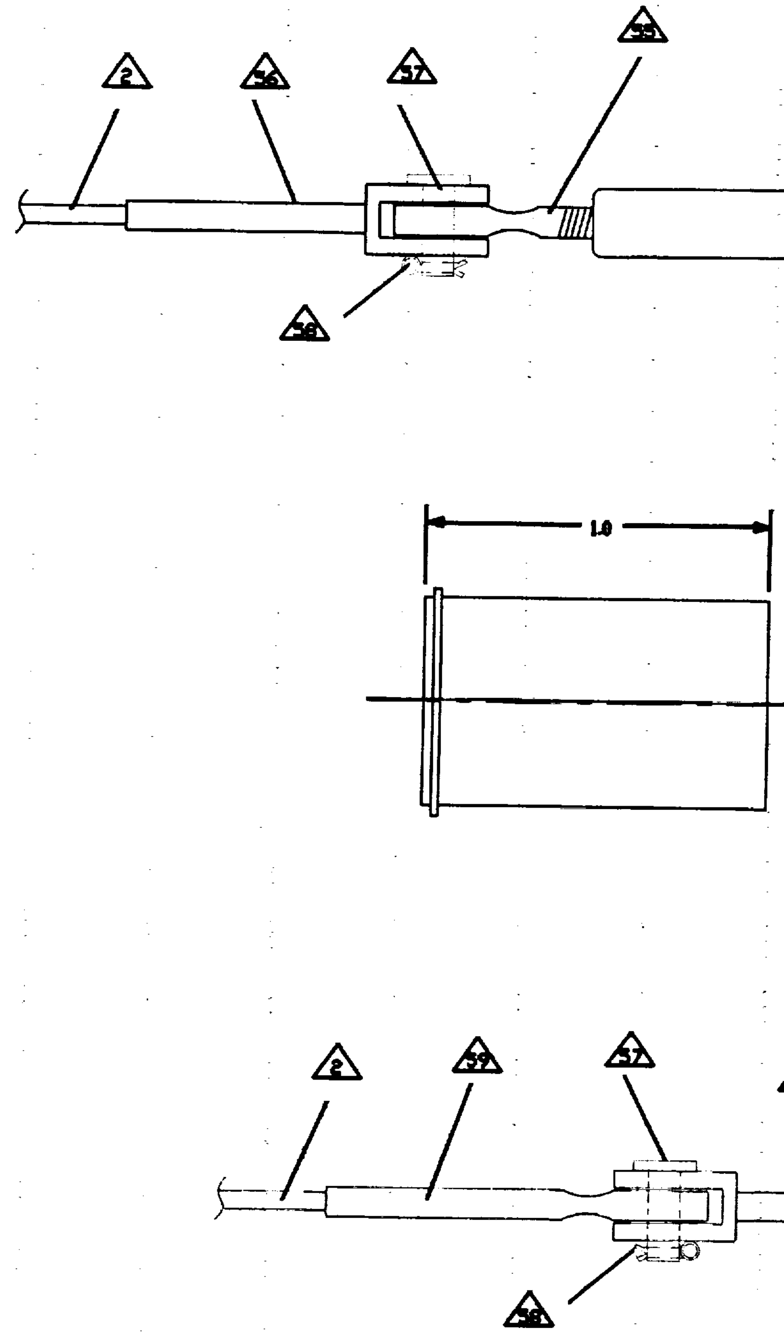

AILERON CABLE CONNECTIO
R/LBL 100.0

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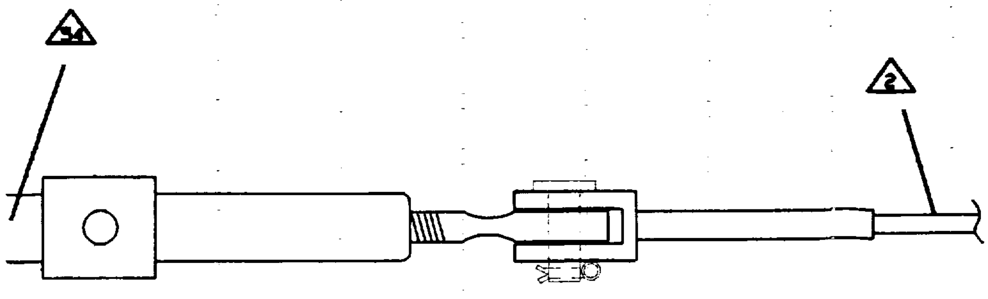
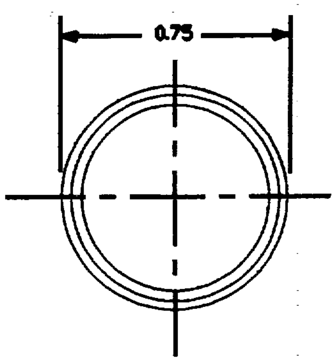
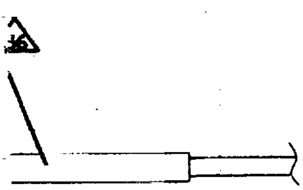


TURNBUCKLE ASSY.
STA 87.0



CABLE FAIRLEAD



ITEM	QTY	DESCRIPTION	SIZE OR NO
59	4	CABLE END EYE TYPE	MS20668-6
58	20	COTTER PIN TYP.	MS24665-208
57	20	CLEVIS PIN TYP.	AN395-9
56	20	CABLE END FORK TYPE	MS20667-6
55	16	TURNBUCKLE END EYE TYPE	AN165-46L
54	8	TURNBUCKLE BARREL	AN155-46L

PARTS LIST

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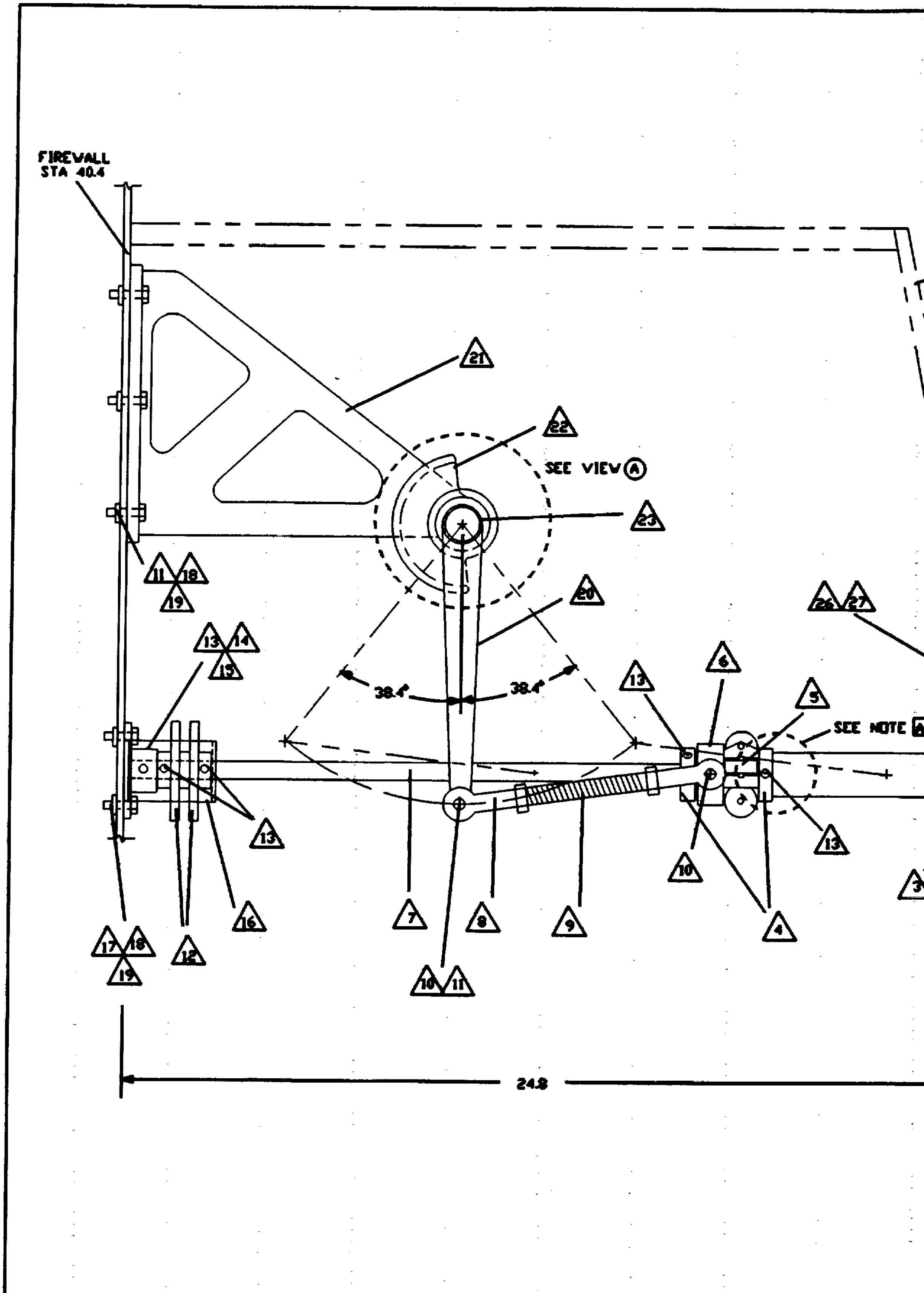

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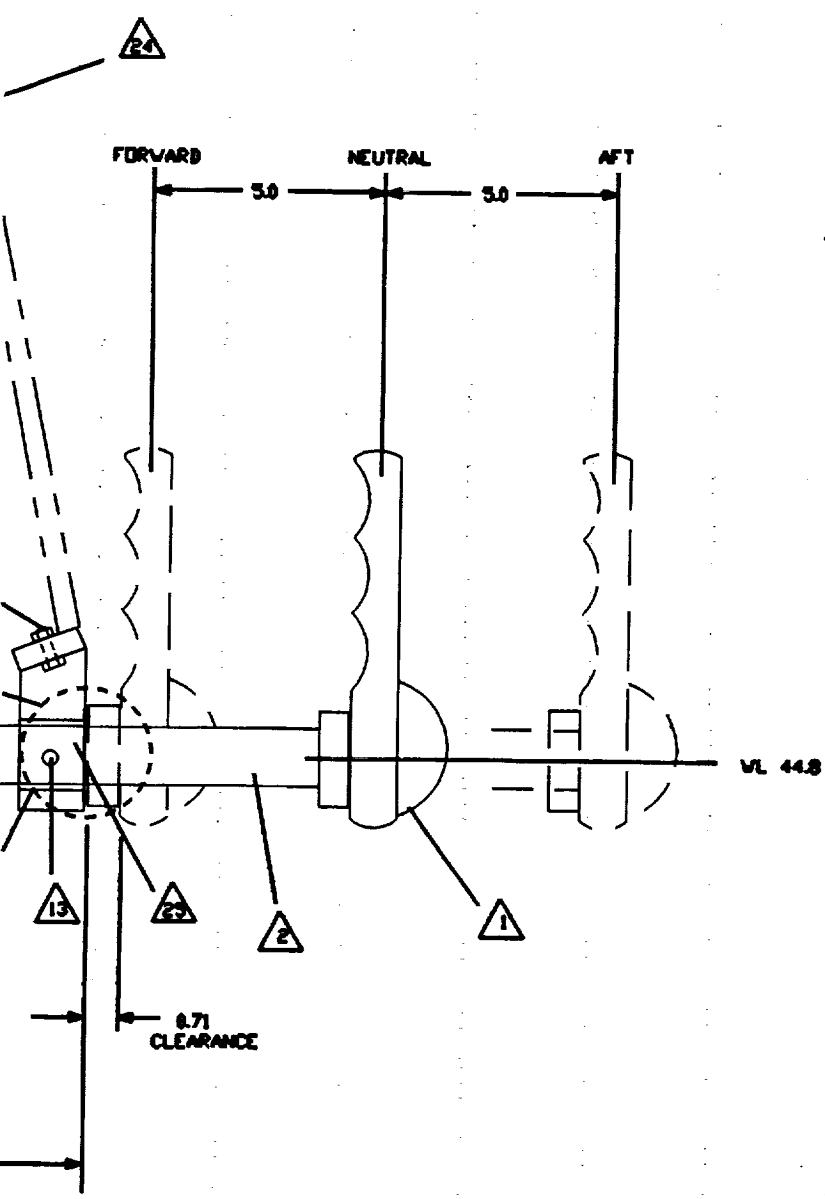

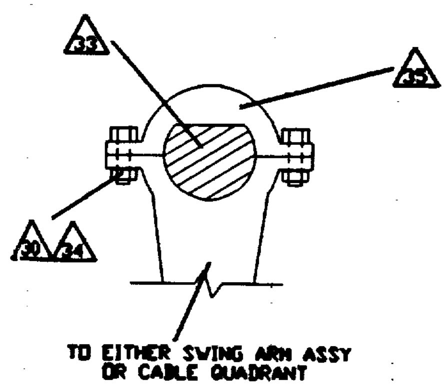

VIEW A

27	4	NUT, TYP.	AN365-524
26	4	BOLT, TYP.	AN5-20
25	2	BEARING HOUSING (CAST 2024)	
24	1	INSTRUMENT PANEL FRAME	
23	4	TUBING, 6061-T6	1.25" O.D.
22	1	ELEVATOR CABLE QUADRANT, DUAL	CAST 7075
21	1	CENTER SUPPORT (CAST 7075)	
20	2	SWING ARM ASSEMBLY (CAST 7075)	7.5" LONG
19	36	RIVET, TYP.	MS20430DD4-5
18	10	NUT, ANCHOR TYPE	AN366F-524
17	4	BOLT, TYP.	AN5-5
16	2	CHAIN GUARD, ALUM. SHEET	0.030" THK.
15	2	FABRIC BEARING, FAFNIR fb hw	0.75" I.D.
14	2	BEARING HOUSING (CAST 2024)	
13	16	SET SCREW	AN526-832-6
12	4	SPROCKET, CHAIN (P.D. 2.868")	25EM26S-36
11	10	BOLT, TYP.	AN5-6
10	8	NUT, TYP.	AN364-524
9	4	ALL THREAD	5/16-24
8	8	ROD END	HFR-5
7	2	TUBING, SQAURE 6061-T6	0.5"x0.5"
6	2	FABRIC BEARING COLLAR	1.25" I.D.
5	2	ROLLER ASSEMBLY	
4	4	COLLAR	1.25" I.D.
3	4	FABRIC BEARING, FAFNIR fb hw	1.25" I.D.
2	2	TUBING, 6061-T6 W/SQUARE HOLE	1.25" O.D.
1	2	CONTROL YOKE, MAGNESIUM	
ITEM	QTY.	DESCRIPTION	SIZE OR NO.

PARTS LIST

NOTE A: FORWARD YOKE LIMIT WHEN YOKE CONTACTS SLIDE BEARING IN INSTRUMENT PANEL.

AFT YOKE LIMIT WHEN COLLAR CONTACTS SLIDE BEARING FROM OTHER SIDE OF PANEL.

.XX ± .01 .XXX ± .001 ± 1/2°	EMBRY-RIDDLE AERONAUTICAL UNIVERSITY DAYTONA BEACH FLORIDA		
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	TITLE COCKPIT YOKE ASSEMBLY		
	DRAWING NO. 421S9303B102		SHEET 01

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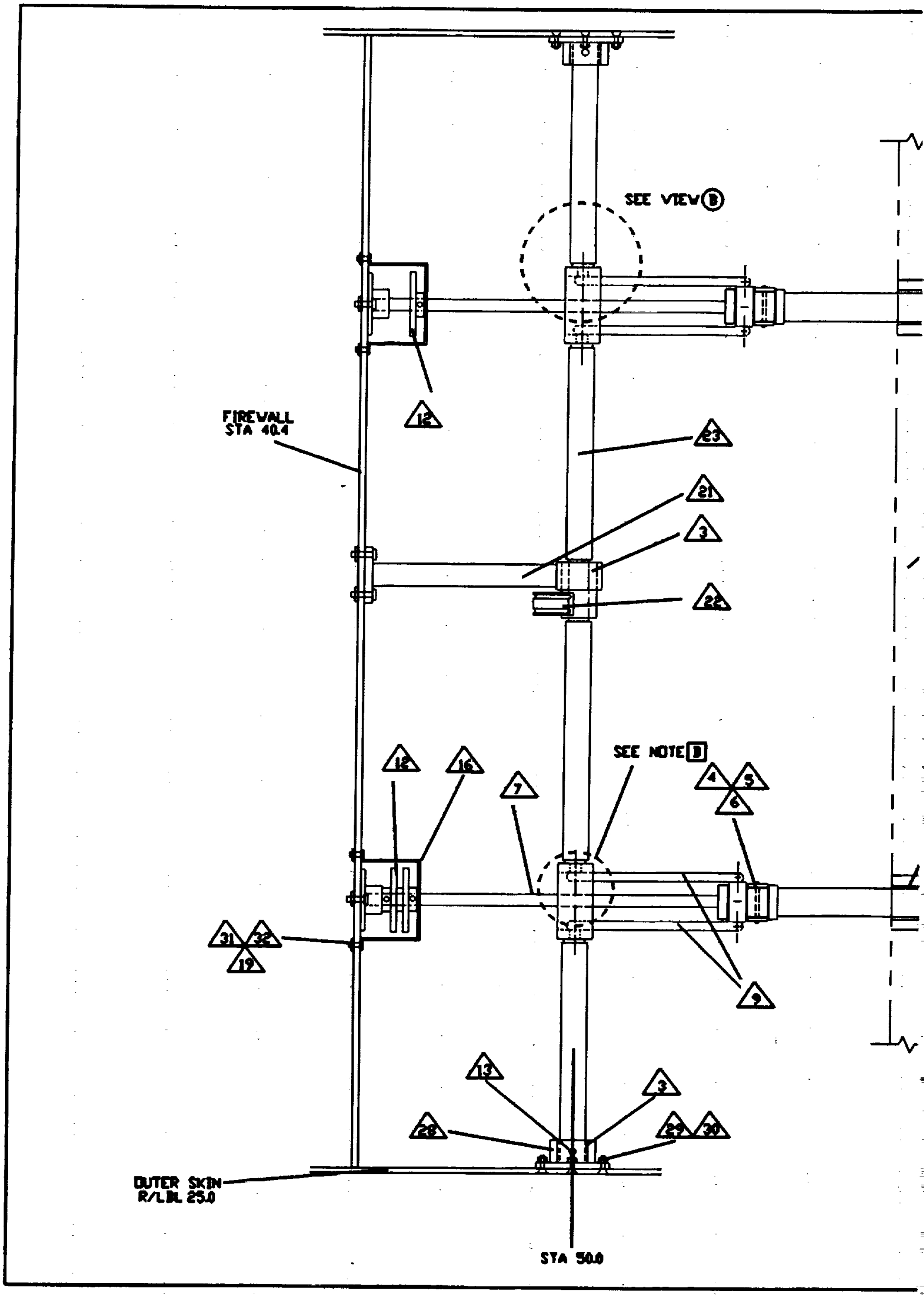

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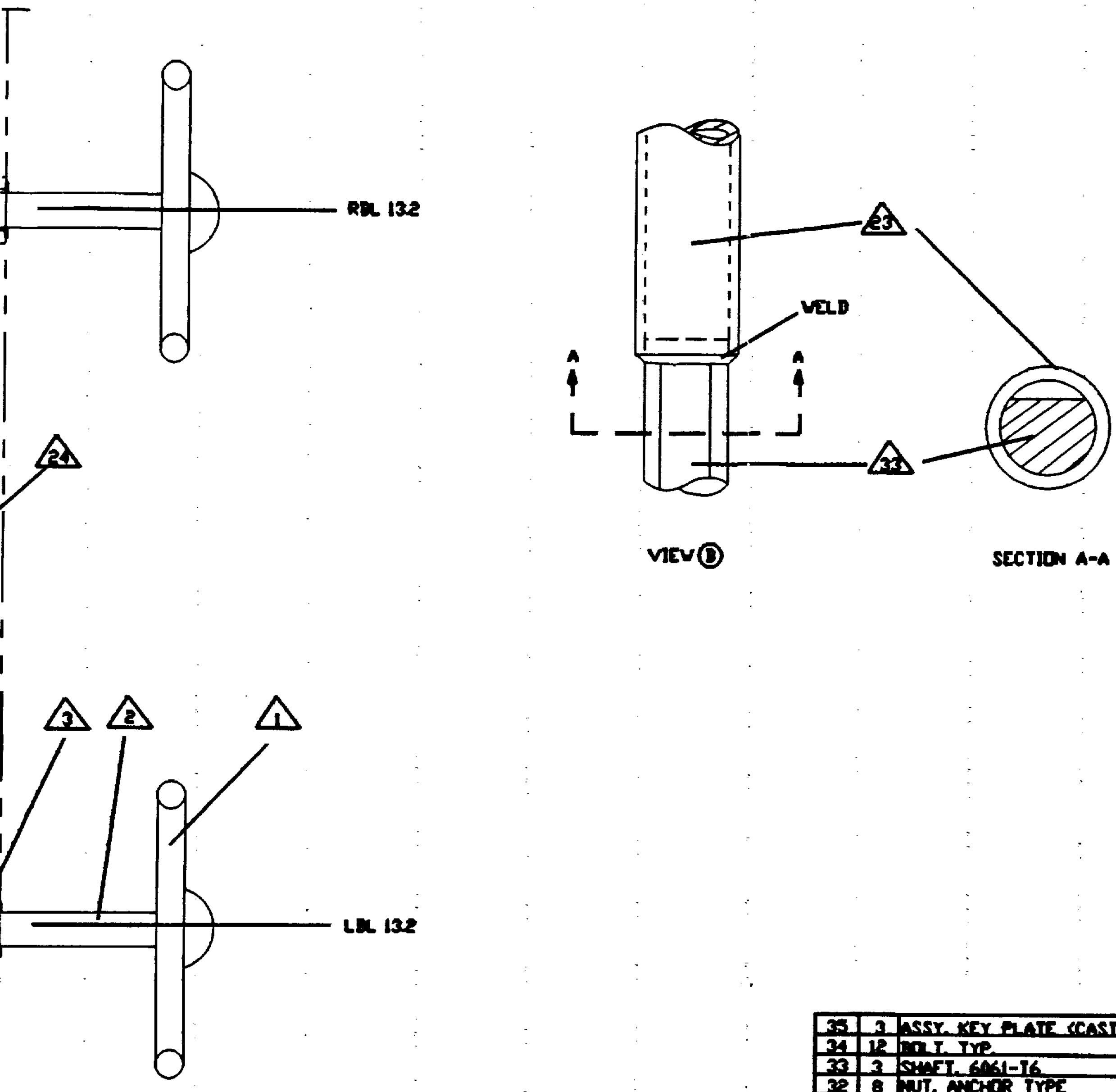


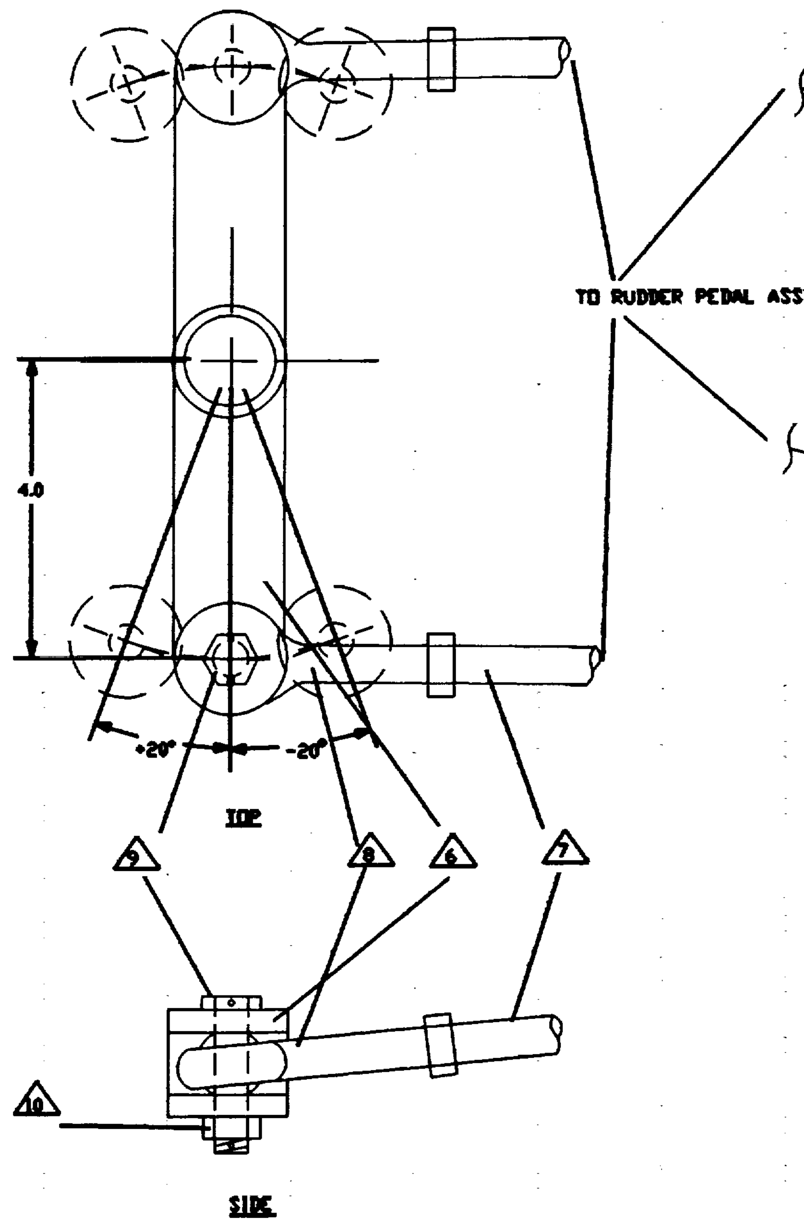
ITEM	QTY.	DESCRIPTION	SIZE OR NO
35	3	ASSY. KEY PLATE (CAST 7075)	
34	12	BOLT, TYP.	AN4-10
33	3	SHAFT, 6061-T6	1.152" O.D.
32	8	NUT, ANCHOR TYPE	AN366F-428
31	8	BOLT, TYP.	MS24694-S99
30	20	NUT, TYP.	AN364-428
29	8	BOLT, TYP.	MS24694-S101
28	2	BEARING HOUSING (CAST 2024)	

PARTS LIST

NOTE B: ATTACHMENTS FOR QUADRANT AND SWING ARM ASSEMBLIES TO ELEVATOR CONTROL TUBE NOT SHOWN FOR CLARITY (SEE 421S9303B102-01)

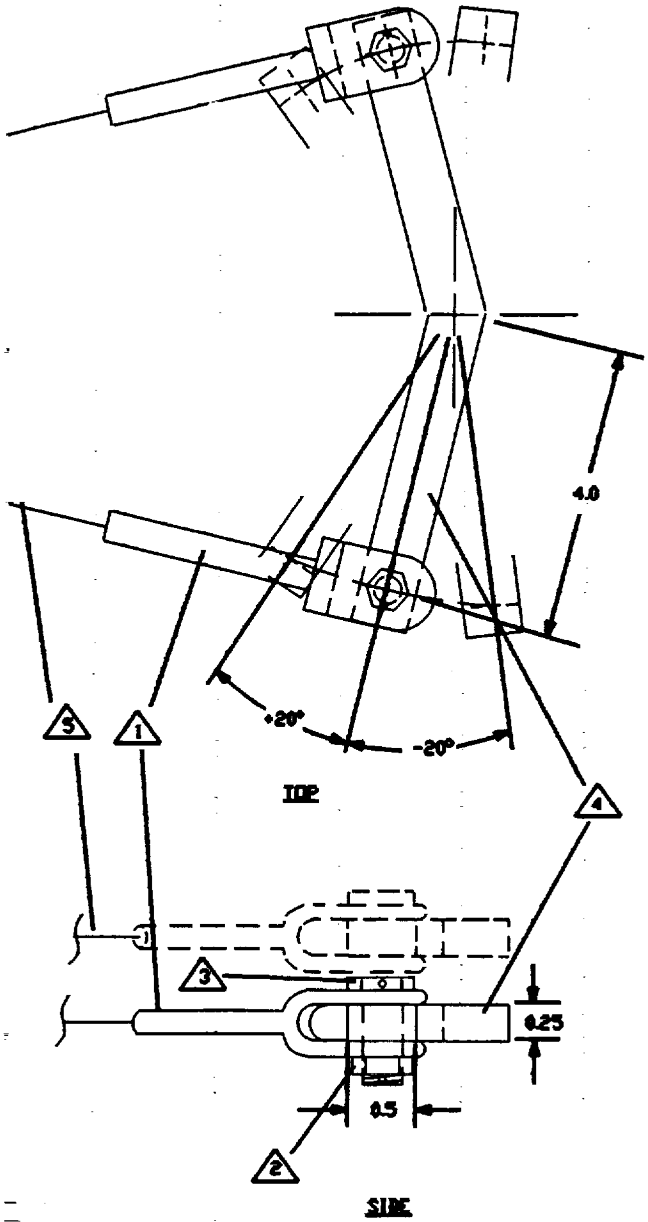
.XX ± .01 .XXX ± .001 ± 1/2°	EMBRY-RIDDLE AERONAUTICAL UNIVERSITY DAYTONA BEACH FLORIDA			
	SIZE B	DATE 12/22/93	SCALE	DRAWN BY G. MEHOLIC
	TITLE COCKPIT YOKE ASSEMBLY			
	DRAWING NO. 421S9303B102			SHEET 02

FOLDOUT FRAME 1.



NOSEWHEEL CONTROL HORN
DETAIL
STA 17.0

FOLDOUT FRAME 2



RUDDER CONTROL HORN
DETAIL
STA 303.0

10	2	NUT, CASTLE TYPE	AN320-6
9	2	BOLT, TYP. (SAFETY WIRED)	AN6H21
8	2	ROD END SWIVEL BALL	HMX-6G
7	2	TUBING STAINLESS (AMS 5561)	1/2" O.D.
6	1	NOSEW'L CONT'L ARM (CAST 1018)	1.8x1.5x8
5	2	CABLE, 7x19 GALVANIZED	3/16" DIA.
4	2	RUDDER HORN (CAST 2024)	0.5x2.5x4.0
3	2	BOLT, TYP. (SAFETY WIRED)	AN5H12
2	2	NUT, CASTLE TYPE	AN310-5
1	2	CABLE FORK END	MS20667-6
ITEM	QTY.	DESCRIPTION	SIZE OR NO.
PARTS LIST			

.XX ± .01 .XXX ± .001 ± 1/2°	EMBRY-RIDDLE AERONAUTICAL UNIVERSITY DAYTONA BEACH FLORIDA			
	SIZE B	DATE 2/22/93	SCALE	DRAWN BY G. MEHOLIC
	TITLE RUDDER/NOSEWH'L HORN DETAIL			
	DRAWING NO. 421S9303B103			SHEET 01

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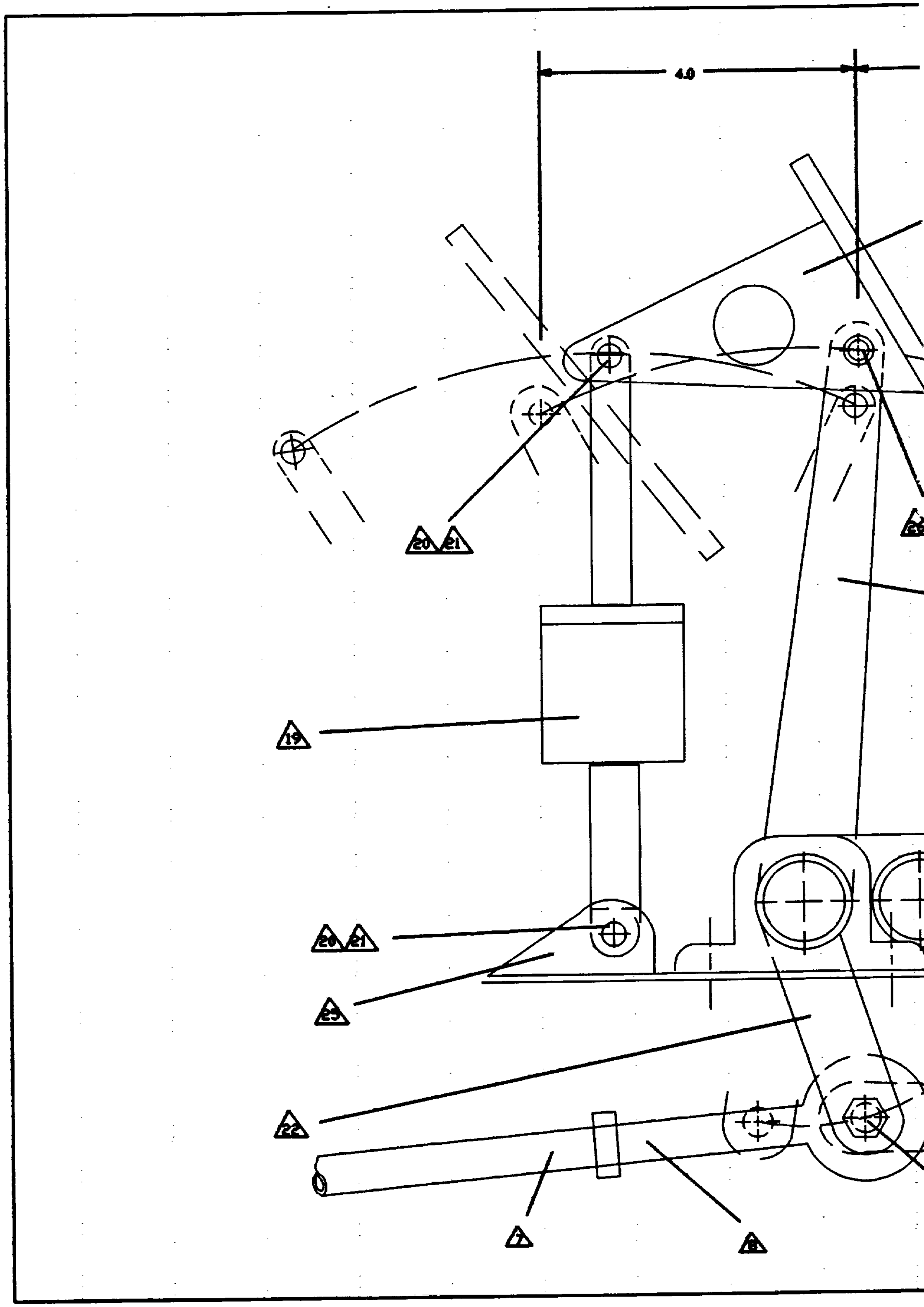

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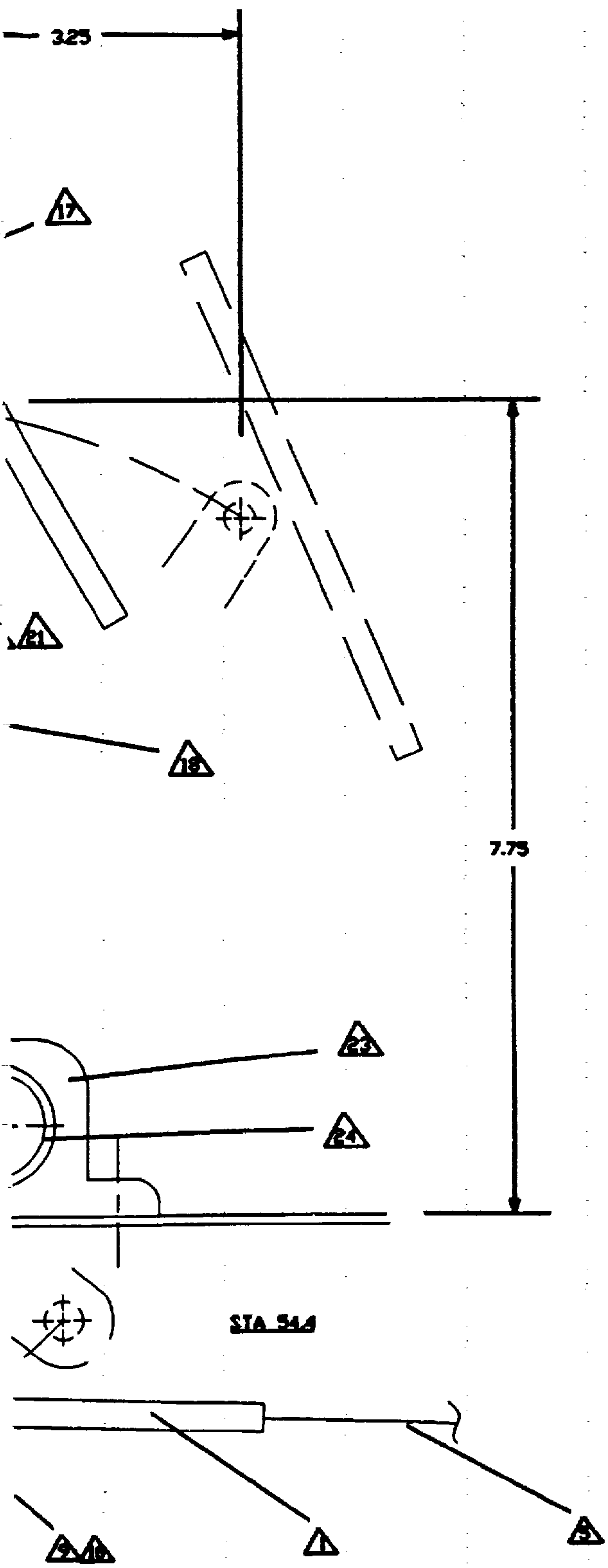
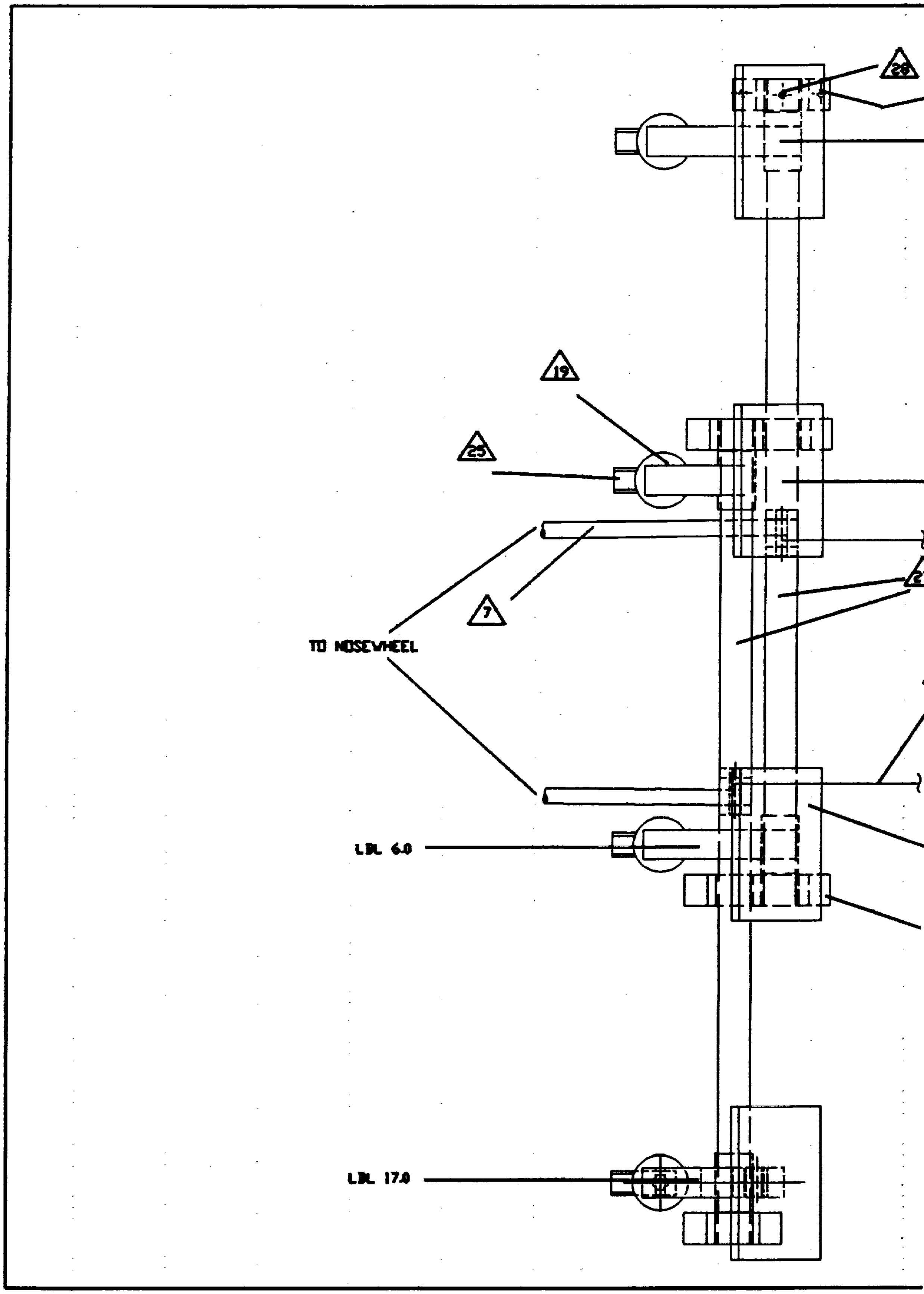


ITEM	QTY	DESCRIPTION	SIZE OR NO.
26	4	BOLT, TYP.	AN4-16A
25	4	FLOOR BRACKET, STEEL SHEET	
24	6	FABRIC BEARING, FAFNIR (b.m	1.25" I.D.
23	4	JOURNAL HOUSING, 2 DBL, 2 SGL	CAST 2024
22	4	LOWER PEDAL ARM (CAST 7075)	3"L x 3"V
21	4	NUT, TYP.	AN364-428
20	4	BOLT, TYP.	AN4-10A
19	4	BRAKE MASTER CYLINDER	MATCO
18	4	UPPER PEDAL ARM (CAST 7075)	1"V x 7"H
17	4	RUDDER PEDAL (CAST 7075)	5"V x 6"H

PARTS LIST

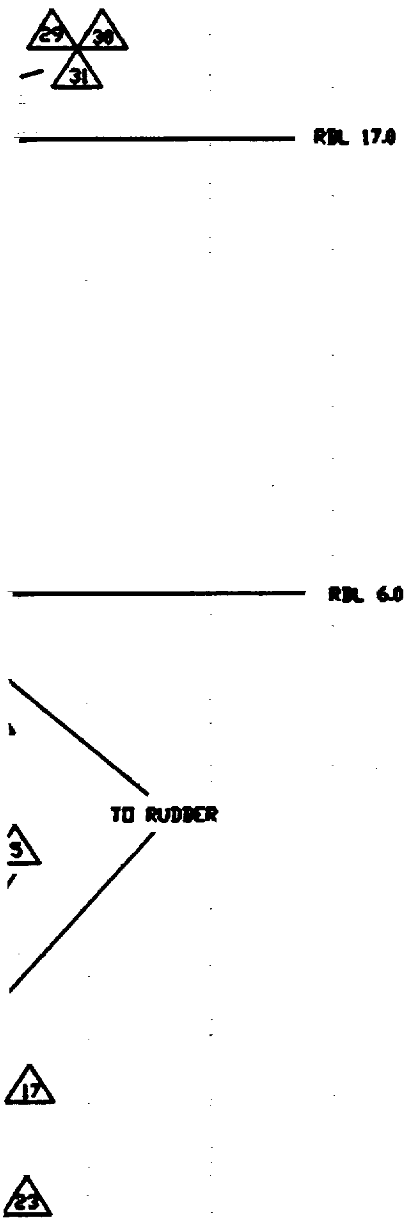
.XX ± .01 .XXX ± .001 ± 1/2°	EMBRY-RIDDLE AERONAUTICAL UNIVERSITY DAYTONA BEACH FLORIDA			
	SIZE D	DATE 2/22/93	SCALE	DRAWN BY G. MEHOLIC
	TITLE RUDDER/BRAKE ASSEMBLY			
	DRAWING NO. 42159303B103			SHEET 02

FOLDOUT FRAME



2.

FOLDOUT FRAME

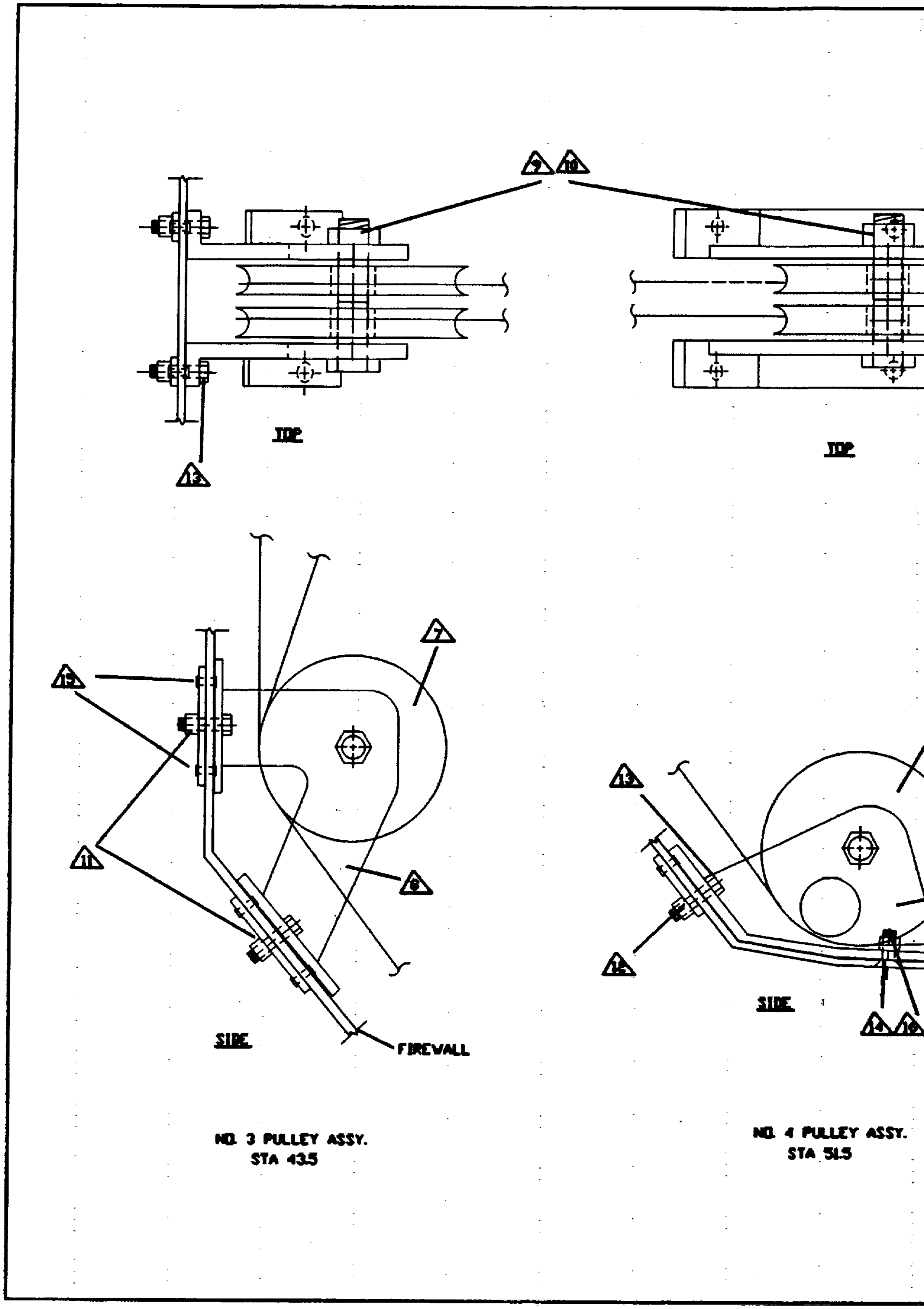


31	16	RIVET, TYP.	MS20430DD8-5
30	8	NUT, ANCHOR TYPE	AN366F-428
29	8	BOLT, TYP.	AN4-5A
28	6	BEARING SET SCREW	AN520-832-6
27	2	RUDDER PEDAL TORQUE TUBE	1.25" O.D
ITEM	QTY.	DESCRIPTION	SIZE OR NO.

PARTS LIST

.XX ± .01 .XXX ± .001 ± 1/2°	EMBRY-RIDDLE AERONAUTICAL UNIVERSITY DAYTONA BEACH FLORIDA			
	SIZE B	DATE 2/22/93	SCALE	DRAWN BY G. NEHOLIC
	TITLE RUDDER/BRAKE ASSEMBLY			
	DRAWING NO. 421S9303B103			SHEET 03

FOLDOUT FRAME /



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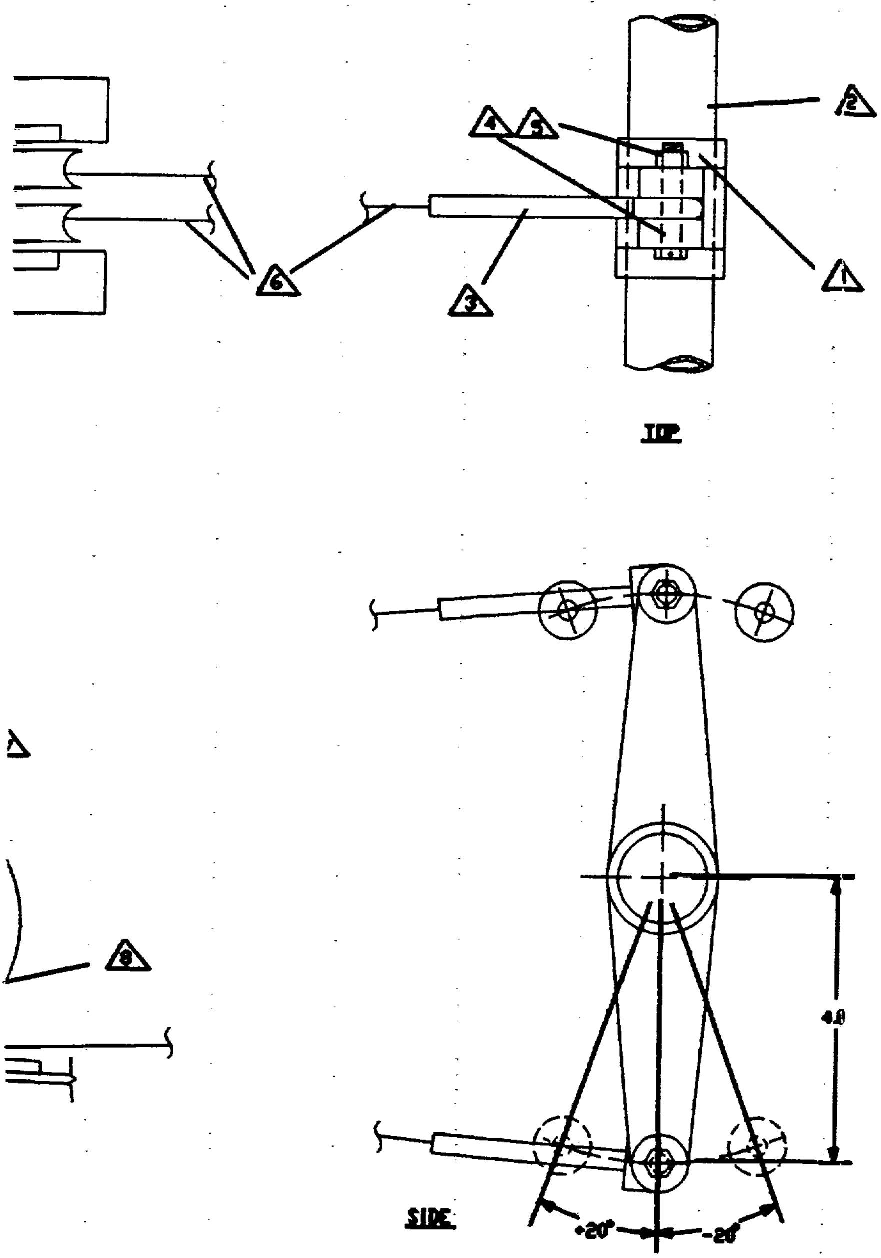
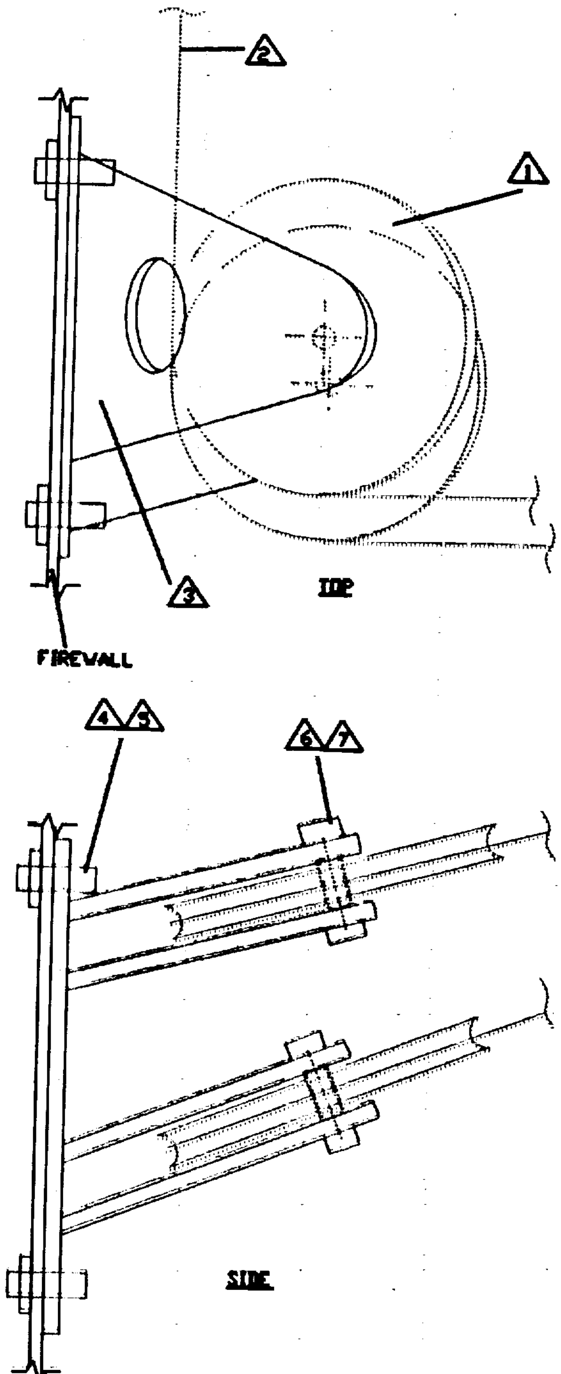


ELEVATOR CONTROL HORN DETAIL
STA 275.0

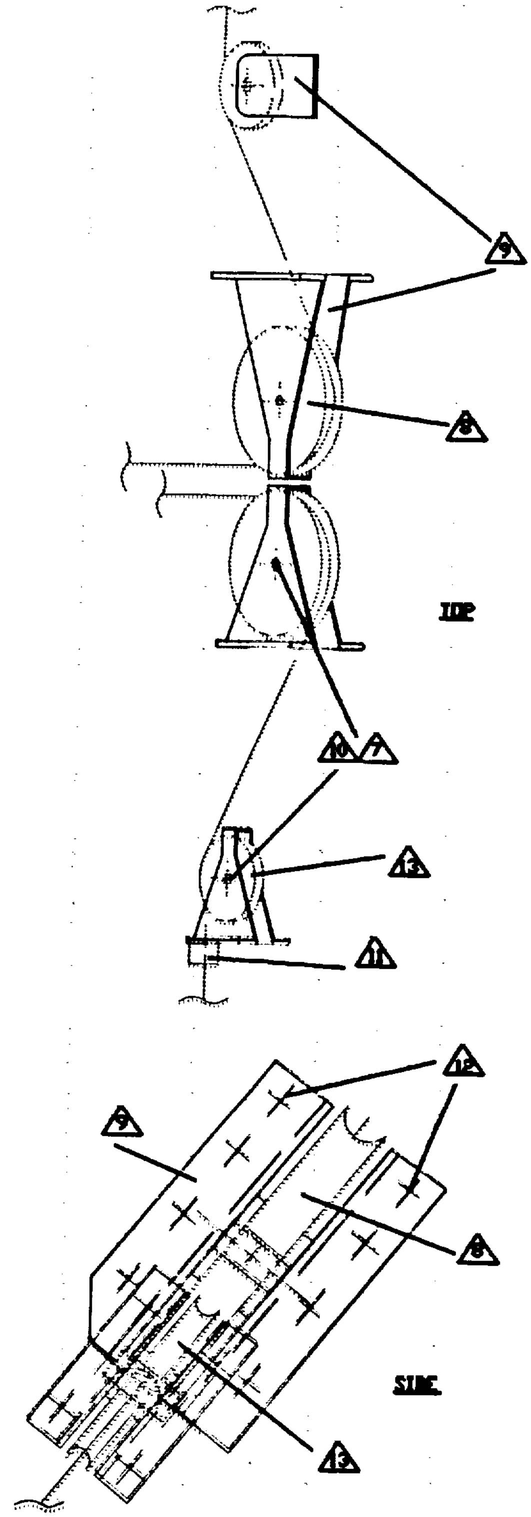
ITEM	QTY.	DESCRIPTION	SIZE OR NO.
16	2	NUT, TYP.	AN364-428
15	12	RIVET, TYP.	MS20430BD3-12
14	2	BOLT, TYP.	NAS334-5
13	6	BOLT, TYP.	AN5-6
12	2	NUT, ANCHOR TYPE	22NA17-054
11	4	NUT, ANCHOR TYPE	AN366F-524
10	2	NUT, TYP.	AN364-820A
9	2	BOLT, TYP.	AN8-23A
8	4	PULLEY MOUNTS (CAST 2024)	0.125" THK.
7	4	CABLE PULLEY, TYP.	AN221-2
6	2	CABLE, 7x19 GALVANIZED	3/16" DIA.
5	2	NUT, CASTLE TYPE	AN310-5
4	2	BOLT, TYP. (SAFETY WIRED)	AN5H14
3	2	CABLE END EYE	MS20668-6
2	1	ELEVATOR TORQUE TUBE (ALUM)	1.25" O.D.
1	1	ELEVATOR HORN (CAST 2024)	1.5x1x8

PARTS LIST

.XX ± .01 .XXX ± .001 ± 1/2°	EMBRY-RIDDLE AERONAUTICAL UNIVERSITY DAYTONA BEACH FLORIDA			
	SIZE B	DATE 2/22/93	SCALE	DRAWN BY G. MEHOLIC
	TITLE ELEVATOR SYSTEM COMPONENT DETAIL			
	DRAWING NO. 421S9303B104			SHEET 01

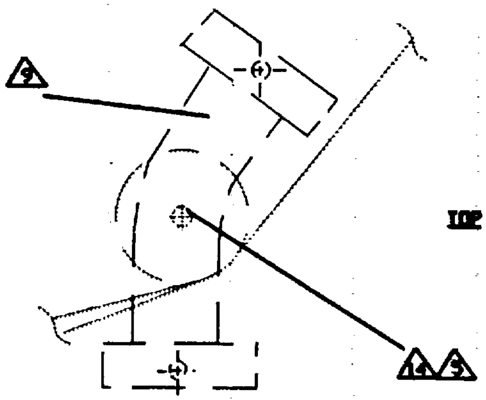


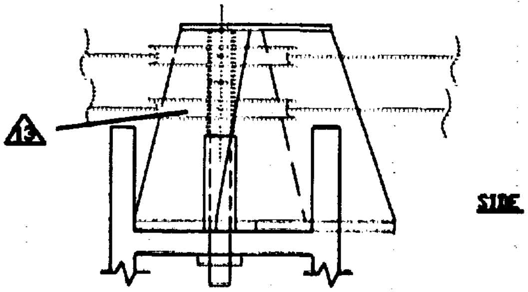
NO. 1 AILERON PULLEY ASSY



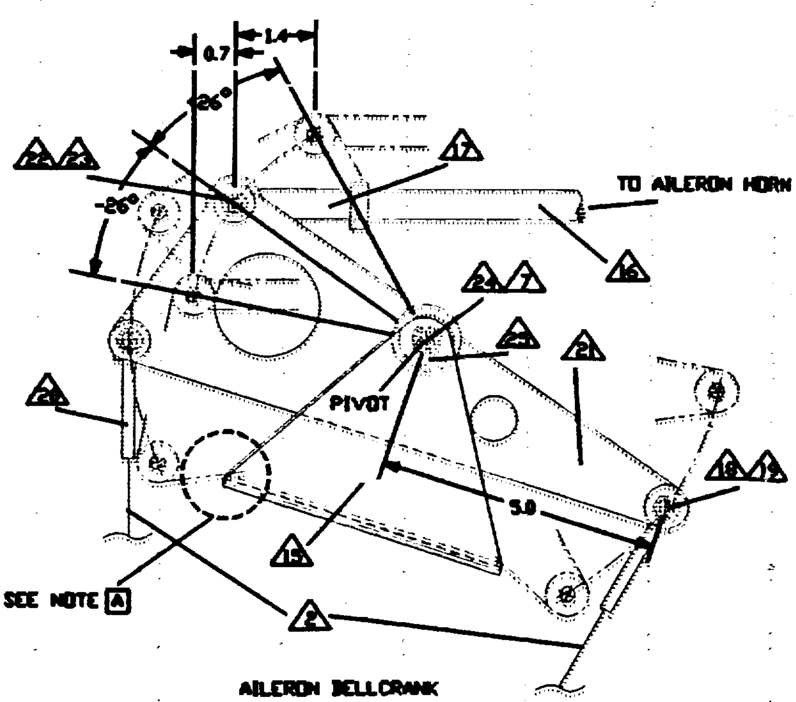
NO. 3 AND NO. 4
AILERON PULLEY ASSY.

FOLDOUT FRAME





NO. 2 AILERON PULLEY ASSY.



AILERON BELLCRANK
TOP VIEW
R/LBL 143.7

NOTE A: AILERON MOTION LIMITED IN BOTH DIRECTIONS WHEN BELLCRANK EDGE CONTACTS BELLCRANK MOUNT

ITEM	QTY.	DESCRIPTION	SIZE OR NO.
25	4	BALL BEARING (FAFNIR KP5)	5/16" I.D.
24	2	BOLT, TYP.	AN5-15
23	4	NUT, CASTLE TYPE	AN320-6
22	4	BOLT, TYP.	AN6H13
21	4	BELLCRANK PLATE (CAST 7075)	0.125" THK.
20	4	CABLE END, EYE TYPE	MS20668-6
19	4	NUT, CASTLE TYPE	AN320-5
18	4	BOLT, TYP.	AN5H12
17	4	ROD END	HMX-6FG
16	2	CONTROL ROD (TUBING 6061-T6)	0.5" I.D.
15	2	BELLCRANK MOUNT (6061-T6 SHT.)	0.063" THK.
14	1	BOLT, TYP.	AN5-35
13	4	CABLE PULLEY, TYP.	AN220-1
12	28	RIVET, TYP.	MS20470DD2-4
11	1	FAIRLEAD, TYP.	3/4" O.D.
10	4	BOLT, TYP.	AN5-12
9	4	PULLEY MOUNT STEEL	0.070" THK.
8	2	CABLE PULLEY, TYP.	AN220-2
7	3	NUT, TYP.	AN364-524
6	2	BOLT, TYP.	AN5-15
5	4	NUT, ANCHOR TYPE	AN366F-524
4	4	BOLT, TYP.	AN5-6
3	1	PULLEY MOUNT, WELDED ALUM.	2024-T6
2		CABLE, 7x19 GALVANIZED	3/16" DIA.
1	2	CABLE PULLEY, TYP.	AN220-3

PARTS LIST

.XX ± .01 .XXX ± .001 ± 1/2°	EMBRY-RIDDLE AERONAUTICAL UNIVERSITY DAYTONA BEACH FLORIDA			
	SIZE B	DATE 2/22/93	SCALE	DRAWN BY G. NEHOLIC
	TITLE AILERON SYSTEM COMPONENT DETAIL			
	DRAWING NO. 421S9303B105			SHEET 01